federal register

Wednesday
January 7, 1981

Part III

Environmental Protection Agency

Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines; Particulate Regulation for Heavy-Duty Diesel Engines

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 86

[Docket No. A-80-18; AMS-FRL-1628-7]

Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines; Particulate Regulation for Heavy-Duty Diesel Engines

AGENCY: Environmental Protection Agency.

ACTION: Proposed rule.

SUMMARY: The proposed regulation would establish a standard for the emission of particulate matter from heavy-duty diesel engines.[1] Beginning with the 1986 model year, this standard would be 0.25 gram per brake horsepower-hour (g/BHP-hr) (0.093 gram per megajoule (g/MJ)). Although this standard represents about a two-thirds reduction in particulate emissions from uncontrolled levels, it is judged feasible without increasing emissions of nitrogen oxides (NOx). The proposed regulation would also amend the emission testing regulations at 40 CFR Part 86 to establish procedures for the measurement of particulate emissions from new heavy-duty diesel engines to determine compliance with the particulate emission standard. In addition, this regulation would incorporate compliance testing of production heavy-duty engines for particulate emissions under the Selective Enforcement Auditing (SEA) program beginning with the 1986 model year.

In a related rulemaking action, EPA will soon propose a revised NOx emission standard for these same heavy-duty diesels, along with revised NOx emission standards for light-duty trucks and heavy-duty gasoline engines for 1986 and later model years. In order to ensure that these two proposals are mutually compatible, EPA will restrict the degree of NOx emission reduction required from heavy-duty diesels to that which is attainable with the proposed particulate standard in effect. This relationship between the two rulemaking actions affecting heavy-duty diesels is outlined in greater detail later in the section entitled *Technology.*

DATES: *Public Hearing:* There will be a public hearing on the provisions of this proposed regulation approximately 45 days after publication of this document. The exact time and place will be announced at a later date in a subsequent **Federal Register** notice.

EPA will consider all written comments received on or before the 30th day following the public hearing. EPA requests that, to the extent possible, comments be submitted prior to the hearing.

ADDRESSES: Interested persons may submit written comments to the: Central Docket Section A-130, West Tower Lobby Gallery 1, U.S. Environmental Protection Agency, Attn: Docket No. A-80-18, 401 M Street SW, Washington, D.C. 20460. Also, EPA requests that commenters forward five copies to U.S. Environmental Protection Agency, Attn: Director, Emission Control Technology Division, 2565 Plymouth Road, Ann Arbor, MI 48105.

Copies of materials relevant to this rulemaking action are contained in Public Docket No. A-80-18 at the U.S. Environmental Protection Agency, Central Docket Section, West Tower Lobby Gallery 1, 401 M Street, S.W., Washington, D.C. 20460. The Central Docket Section is open to visitors Monday through Friday from 8:00 a.m. to 4:00 p.m. (As provided in 40 CFR Part 2 the Agency may charge a reasonable fee for copying services.)

FOR FURTHER INFORMATION CONTACT: Richard A. Rykowski, Environmental Protection Agency, 2565 Plymouth Road, Ann Arbor, MI 48105, Telephone: (313) 668-4339 (FTS) 374-8339.

SUPPLEMENTARY INFORMATION:

Comments and the Public Docket: During final rulemaking EPA will consider all written comments received on or before the 30th day following the public hearing. EPA requests that, to the extent possible, comments be submitted prior to the hearing. EPA will keep the record of the public hearing open for submission of rebuttal and other information following the close of the hearing until the above mentioned date.

It is EPA's intention to assure all interested parties an opportunity to study all information which may become the basis for EPA's final action in this proceeding. Accordingly, the Agency will not consider in this rulemaking any material which cannot be made publicly available. Parties who wish to submit information in response to this Notice of Proposed Rulemaking are cautioned that EPA will not consider, but will return to the commenter, any comments which are claimed, in whole or in part, to be confidential.

Authority: Statutory authority and mandate for this action are provided under Sections 202, 206 and 301(a) of the Clean Air Act (42 U.S.C. 7521, 7525 and 7601). Section 202(a)(3)(A)(iii) of the Act provides that, "The Administrator shall prescribe regulations under paragraph (1) of this subsection applicable to emissions of particulate matter from classes or categories of vehicles manufactured during and after model year 1981 (or during any earlier model year, if practicable)." Section 206(a)(1) provides, in part, that "the Administrator shall test, or require to be tested in such manner as he deems appropriate, any new motor vehicle . . . to determine whether such vehicle . . . conforms with the regulations prescribed under Section 202 of this Act." Section 301(a) provides, in part, that "the Administrator is authorized to prescribe such regulations as are necessary to carry out his functions under this Act."

Background: Despite significant gains made in the control of total suspended particulate (TSP) emissions from stationary sources, there are still many air quality regions which are not able to meet the primary National Ambient Air Quality Standard (NAAQS) for TSP of 75 micrograms per cubic meter. As diesel engines continue over time to power an even greater portion of the nation's heavy-duty vehicles (on-the-road trucks and buses whose gross vehicle weight rating exceeds 8,500 pounds), their contribution to ambient levels of total suspended particulate (TSP) will increase over levels that are already significant. Current heavy-duty diesels emit more than twice the particulate per mile emitted by heavy-duty gasoline engines operated on leaded gasoline. Beginning with the 1984 model year, heavy-duty gasoline engines will for the most part be equipped with catalysts in order to comply with stringent standards for hydrocarbons and carbon monoxide. These engines will then be operating on cleaner burning unleaded gasoline and their particulate emissions will decrease by 95-98 percent. Thus, without regulation, heavy-duty diesels will emit 40-100 times the particulate emitted by these 1984 and later model year gasoline engines. Also, due to the extremely low levels of particulate emissions expected from future heavy-duty gasoline engines, EPA does not plan to propose a particulate emission standard for these engines. Table 1 lists particulate emission levels from some heavy-duty diesels currently being used.

If current trends continue, EPA expects the use of diesel engines in heavy-duty vehicles to increase dramatically over the next 15 years. While diesel engines currently power about one-third of all new heavy-duty vehicles sold in the U.S., EPA expects this percentage to increase to 57-69 percent by 1995. This move toward more diesels will increase nationwide particulate emissions from heavy-duty diesels to an estimated 218,000-266,000

[1] A heavy-duty diesel engine is any diesel engine used to power a heavy-duty vehicle, which is an on-the-road vehicle whose gross vehicle weight rating exceeds 8500 pounds or whose frontal area exceeds 45 square feet.

metric tons per year by 1995. Urban areas would be the most heavily affected by these emissions. Ambient particulate levels from heavy-duty diesels alone would reach 2–7 micrograms per cubic meter (annual geometric mean) in cities such as Chicago, Los Angeles, New York, and Dallas. Somewhat lower levels of 2–5 micrograms per cubic meter (annual geometric mean) would occur in smaller cities such as St. Louis, Denver, and Phoenix. These levels would occur over large-scale areas within these cities. Additional particulate levels of 5–6 micrograms per cubic meter (annual geometric mean) would be expected in localized areas within 90 meters of very busy roadways.

Table 1

Engine*	Particulate emissions (g/BHP-hr)	Number of tests
1978 Caterpillar 3208	0.79	7
1979 Caterpillar 3406 (Family 10)	.37	2
1979 Caterpillar 3406 (Family 16)	.52	2
1976 Cummins NTC–350	.60	4
1979 Cummins NTC–350 "Big Cam"	.40	2
1979 Cummins NTCC–350	.39	2
1979 Cummins NTC–290	.58	2
1979 Cummins VTB–903*		
No. 1 Fuel	.31	2
No. 2 Fuel	.37	2
1978 DDA 6V–92T	.54	2
1978 DDA 8V–71N*		
No. 1 Fuel	.69	2
No. 2 Fuel	.79	2
1979 DDA 8V–71TA	.38	2
1979 DDA 6V–92TA*6g		
No. 1 Fuel	.48	2
No. 2 Fuel	.55	2
1979 DDA 6V–92TA 10g	.54	2
1979 IHC DTI–466B	.36	2
1979 IHC DT–466	.53	2
1979 Mack ETAZ(B)673A	.58	2
1980 Mack ETSX–676	.63	2

*Engines operated on No. 2 fuel except where noted.

A description of the standard being proposed follows together with a description of the technological, environmental and economic impacts of this regulation. Following these topics are discussions of 1) the alternatives examined by EPA, 2) the major areas of the current Federal Test Procedure that would be changed by the proposed particulate test procedures, 3) the alternative particulate measurement techniques considered for the Federal Test Procedure, and 4) the major differences between the proposed test procedure and that contained in EPA's Draft Recommended Practice of April 1979.

Proposed Standard: The proposed particulate standard for heavy-duty diesel engines is 0.25 gram per brake horsepower-hour (g/BHP/hr) (0.093 gram per megajoule (g/MJ)) beginning with the 1986 model year. Heavy-duty diesel engines must also continue to meet the appropriate gaseous emission standards for hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NO^x) and smoke standards.

The proposal does not affect the current certification or selective enforcement audit (SEA) processes. It does, however, modify test procedures to provide for particulate measurement. As manufacturers of heavy-duty diesels must currently follow these procedures to demonstrate compliance with gaseous emission and smoke standards, the same will hold true for this particulate standard. The use of a full useful-life deterioration factor, the use of a 10 percent acceptable quality level for SEA and the certification engine selection criteria will all apply to this particulate standard as they will for the HC, CO, NO_x, and smoke standards. However, because the proposed test procedure will provide both particulate and gaseous emission values simultaneously, EPA does not expect this proposed particulate standard to increase the number of engines requiring testing for either certification or SEA.

Technology: The Clean Air Act as amended in August 1977 requires heavy-duty diesel particulate emission control based upon control technology which the Administrator determines will be available for the model year to which such standards apply. Due consideration must also be given to cost, noise, energy, and safety. The 0.25 g/BHP-hr (0.093 g/MJ) standard being proposed today fulfills these requirements.

EPA has, in the course of developing this proposal, tested heavy-duty diesel engines from each of the 5 major manufacturers in order to determine their particulate emission levels; the transient test procedure as described in the "Draft Recommended Practice for Measurement of Gaseous and Particulate Emissions from Heavy-Duty Diesel Engines Under Transient Conditions," April 1979, was used. Together, the engines produced by these five manufacturers account for approximately 97 percent of the heavy-duty diesel engines sold in this country. The particular engines tested by EPA represent the complete range of engine sizes and applications found in today's fleet and account for roughly 70 percent of U.S. sales. To date, this test program is approximately 80 percent complete. EPA does not believe that delaying this proposal to allow for the completion of this testing is necessary since 1) testing has already been completed on 3 of the 5 major manufacturers' engines, 2) given the representativeness of the tested engines of the other 2 manufacturers and the methodology used to determine the technologically feasible engine-out particulate level (discussed below), it is unlikely that the level of the proposed standard would be significantly affected by the remaining few engines, and 3) the test program will be completed before promulgation of the final standard. If changes to the standard are warranted based on this new data, the comment period will be reopened.

EPA based the level of this proposed standard on:

1. An engine-out particulate emission level of 0.41 g/BHP-hr (0.153 g/MJ);
2. A 60 percent reduction in engine-out particulate emissions from the application of trap-oxidizers;
3. Over the full useful life, an increase in particulate emissions of up to 20 percent due to engine and trap-oxidizer deterioration; and
4. A 24 percent allowance based on 12 percent variability in the particulate emissions of production engines and a 10 percent acceptable quality limit for a Selective Enforcement Audit. These four points are discussed below.

1. Engine-Out Emission Level

The 0.41 g/BHP-hr engine-out emission level represents the level of particulate emissions which EPA has determined to be technologically feasible by 1986 without the use of aftertreatment devices (i.e., trap-oxidizers) and without taking into consideration in-use deterioration or production variability. This level represents the average of the set of engines made up of each manufacturer's lowest particulate emitting model tested by EPA on No. 2 diesel fuel (see Table 1). This approach was chosen from among several alternatives because it best satisfies the Clean Air Act requirements that the standard "reflect the greatest degree of emission reduction achievable . . . giving appropriate consideration to the cost . . . and to noise, energy, and safety factors . . .."

EPA considered three other approaches in determining the technologically achievable level of engine-out particulate emissions. They were: (1) the worst baseline engine (highest particulate emission level), (2) the lowest particulate emission level among the tested engines, and (3) the highest single emission level among each manufacturer's best engines.

The first option would set the feasible level of engine-out particulate emissions at 0.79 g/BHP-hr (0.29 g/MJ) (See Table 1). Using the engine-out particulate emissions of the "worst" baseline engine or vehicle as the starting point for setting the particulate standard may be an appropriate approach when vehicle parameters, such as engine size or

vehicle weight, are a significant factor in the resulting level of emissions. This approach was followed to some extent in setting the particulate emission standards for light-duty vehicles and light-duty trucks (45 FR 14496, March 5, 1980). Particulate emissions from light-duty vehicles and trucks are directly affected by such parameters as vehicle weight and engine size. EPA found that the differences in particulate emissions of baseline light-duty vehicles were not so much the result of different design features leading to lower particulate levels that could be readily incorporated into other vehicles, but rather the fact that generally heavier vehicles tend to emit greater levels of particulate emissions. In order to avoid setting standards (based on the level achievable by the "best" or smallest vehicles) that would have prevented all light-duty diesels from meeting the standards except subcompacts and small pick-ups with small engines, the Agency based the standards on the lowest particulate level achievable by the "worst" (or largest) diesel-powered baseline vehicle.

However, using the engine-out particulate emissions of the "worst" heavy-duty engine as the starting point for setting the heavy-duty particulate standard would be inappropriate because EPA could find no significant correlation between emissions and such parameters as engine size or type. In fact, EPA found a baseline engine with much lower emissions that was comparable in terms of horsepower and in-use application to the baseline engine which had the highest particulate emissions. The results of EPA's investigation suggest that at least to some extent some engine design features leading to lower particulate emissions (from the worst baseline engine) are available.

Given these findings, EPA could not determine that 0.79 g/BHP-hr represented the "greatest reduction achievable . . ." and Option 1 had to be rejected. To do otherwise would have ignored the reduction potential already demonstrated by every other engine tested to date.

Option 2 would require all engines to reach an engine-out particulate level demonstrated by the best of the baseline engines tested. This level is 0.31 g/BHP-hr (0.12 g/MJ); refer to Table 1. Implicit in the choice of this option would be the judgment that (1) there are no engine design features that have an effect on particulate emissions which cannot be readily incorporated on all other heavy-duty diesels, regardless of their size, application (truck or bus), or manufacturer, and (2) the features would produce exactly the same low particulate emission level on all engines. EPA has examined the relationship between particulate emissions and engine size or application and has found no significant correlation. Differences were found in the emissions of engines produced by various manufacturers, but no evidence was found to indicate that the designs used to obtain low emissions on some engines were not available to all manufacturers. However, EPA could not find evidence that these design features would have exactly the same effect on every manufacturer's engines, unless each manufacturer would produce an exact replica of the lowest-emitting baseline engine. For example, the primary cause of the low particulate emissions produced by the best baseline engine may have been an improved fuel injection technique which is available to all manufacturers. However, because the fuel injection system is an integral part of the engine and its efficiency could depend on many other engine parameters (whose effect on particulate emissions are not at this time fully understood), the only way to determine the effect of a modification on a given engine would be to test it on that engine. While EPA could have theoretically performed enough tests on a sufficiently large sample of engines in an attempt to demonstrate that all engines could achieve the emissions of the best baseline engine, the cost of such a program would be enormous and the implementation of this particulate standard would have been postponed by at least 1–2 years. This delay would be unacceptable given the mandate of the Clean Air Act. Given the available data, a standard based on Option 2 might well require the major redesign of virtually all engine families for compliance to be assured. EPA has no basis for supporting the contention that such a major redesign effort would even be possible.

Thus, if EPA chose this approach, it would be possible that a large number of engines might not be able to meet the particulate standard in 1986. In this case, the affected manufacturers could only introduce these engines into commerce if they elected to pay a nonconformance penalty on each engine. While EPA believes that nonconformance penalties have a definite role to play in the regulation of heavy-duty vehicles, we do not believe that Congress intended for nonconformance penalties to be paid in order for most engines to be sold. Yet this situation could arise under Option 2.

Option 3 would use as the starting point for setting the standard the highest single engine-out particulate level from the set of engines made up of each of the five major manufacturer's lowest emitting engine. In other words, Option 3 would set the engine-out particulate level at 0.58 g/BHP-hr (0.22 g/MJ) (see Table 1). An examination of Table 1 shows that a full two-thirds of the engines tested are already emitting less particulate than this level. Thus, this option involves the same problem as discussed above with Option 1; it does not give adequate consideration to the control technology already demonstrated by a substantial majority of the engines being produced today. Thus, while this option might appear to solve the problem of Option 2, that of completely ignoring manufacturer-to-manufacturer differences, it raises the same problem associated with Option 1 and EPA had to reject it from further consideration.

The option chosen by EPA, which bases the feasible level of engine-out particulate emissions on the average of the emission levels of the lowest-emitting engine from each of the five major manufacturers, addresses the problems presented by each of the previous three options and best fulfills the congressional mandate to develop a particulate standard which reflects "the greatest degree of emission reduction achievable . . . giving appropriate consideration to the cost . . . and to noise, energy, and safety factors . . ." It takes into consideration, for example, the ability of several manufacturers to build engines which emit relatively low levels of particulate (see Table 1). Failure to give adequate consideration to such accomplishments (as is the case with options 1 and 3) would be contrary to the above stated requirements of the Clean Air Act. Since 4 of the 5 major manufacturers have already demonstrated their ability to build engines below the 0.41 g/BHP-hr engine-out level (these engines represent approximately 20 percent of domestic sales), the cost or feasibility of extending these techniques to other engine families should not be prohibitive and the widespread use of non-conformance penalties should not be necessary—unlike the scenario presented by Option 2. The fifth manufacturer should also be able to comply since (1) its demonstrated ability to build low-NO_x-emitting engines should lessen its possible reliance on NO_x control techniques which increase particulate emissions (relevant discussions of this point can be found in other portions of this document) and (2)

the leadtime available should be sufficient to allow it to incorporate design features of other manufacturers' engines which have already been demonstrated to lower particulate emissions.

By averaging the particulate emission levels of the best engines, the chosen approach recognizes basic manufacturer-to-manufacturer design differences and reflects a more representative range of performance capabilities than other options based on the performance of single engines. The level of 0.41 g/BHP-hr (0.15 g/MJ) is thus a stringent level to use as a starting point, requiring the higher-polluting engines to incorporate, to a great degree, the demonstrated technology of the best engines of a given manufacturer. Yet at the same time it takes into consideration the uncertainties that would be involved in forcing a manufacturer to adopt almost completely the designs employed by its competitors.

While it is possible that a more stringent engine-out level could be identified that would be technologically feasible, EPA does not have sufficient data at this point to support the utilization of such a level. Further study would be required before a more stringent level could be identified and adequately supported. This would only serve to further delay implementation of the standard. Therefore, EPA believes that it is more appropriate to utilize the engine-out level that is supported by the available data. EPA will continue its research in this area and if it becomes evident that a more stringent engine-out level is technologically feasible, EPA will commence a rulemaking to revise the standard accordingly.

Up until this point, we have restricted the discussion of engine-related technology to that already present on existing engines and avoided discussing additional engine modifications which could also reduce particulate emissions. One promising long-term technique in this latter category is to modify the engine to burn methanol. Methanol is an attractive alternative fuel since it (1) can be readily producible from plentiful domestic sources such as coal and biomass, (2) can possibly be produced by more thermally efficient and evironmentally acceptable processes than processes which yield synthetic crudes, (3) can be produced with readily available, commercially proven technology which appears to require less capital investment than syncrude production processes, and (4) appears to have the potential for very low particulate, hydrocarbon and biologically active organic emissions. The potential for reduced particulate emissions makes methanol a promising alternative fuel with regard to this proposed particulate standard. While the proposed particulate standard is achievable without using methanol, its availability and use would simplify the task immensely.

Also of interest is methanol's inherent ability to lower oxides of nitrogen (NO_x) emissions from diesel engines, compared to those same engines operating on diesel fuel. This result is primarily due to the lower combustion temperature of methanol-fueled diesel engines. Since Congress has required that NO_x emissions be significantly reduced from this class of vehicles (this topic is discussed below), use of methanol could aid in achieving this goal.

In order to evaluate the emissions-related characteristics of diesel engines operating on methanol, EPA is conducting tests on a dual-fueled Volvo heavy-duty diesel engine. Combustion is initiated in this engine when a relatively small quantity of diesel fuel is injected into the heated combustion chamber; the second fuel, methanol in this case, is then injected and ignited by the burning diesel fuel and serves as the primary source of energy for the engine. Completely separate injection systems accommodate the different fuels in this system. Tests of other methanol-burning engines are planned for the future.

Since methanol has the potential to help lessen the nation's dependence on foreign oil as well as provide a means of attaining cleaner air, EPA invites comments on its use in diesel engines.

In addition to the use of methanol fuel, there are other techniques available which also can reduce engine-out particulate emissions from heavy-duty diesel engines. However, some of these techniques also tend to increase emissions of nitrogren oxides (NO_x).[2] This could be problem, since in addition to mandating particulate control Congress also mandated that NO_x emissions from heavy-duty diesels be reduced significantly in 1985. Specifically, NO_x emissions are to be reduced by 75 percent from uncontrolled gasoline engine levels, which translates to about a 1.7 g/BHP-hr standard. The information available to EPA to date has not shown this NO_x level to be feasible for diesels except by using techniques such as retarded timing which increase fuel consumption and increase particulate emissions markedly. Thus, diesels will need every bit of NO_x control that can be found to reach this level. Particulate controls that actually increase NO_x emissions would only aggravate this situation. Thus, EPA will not factor the particulate reductions available from these techniques into its determination of the greatest particulate reduction achievable from heavy-duty diesels.

However, there are some techniques available which can reduce engine-out particulate emissions with increasing NO_x emissions. Data available to EPA has shown that modifications made to a Cummins engine and different modifications made to a Caterpillar engine both resulted in lower particulate emissions and lower NO_x emissions. In addition, the latter engine was already a relatively low particulate emitter. These results, plus the general fact that particulate emissions have yet to be directly controlled and consequently, have yet to be factored into design decision, support the conclusion that engine-out particulate emissions could be reduced below the 0.41 g/BHP-hr level without increasing NO_x emissions.

Before applying these reductions to the 0.41 g/BHP-hr particulate level, however, the Congressional mandate to reduce NO_x emissions must be considered once again. This mandate is very specific, requiring reductions to a specified level. The Congressional mandate to reduce particulate emissions is somewhat less specific, calling only for the greatest reduction achievable without specifying a level. It appears that if diesels are to meet or even approach a NO_x level of 1.7 g/BHP-hr, some increase in particulate emissions may have to result. If the particulate reductions mentioned above were left to offset increases in particulate emissions due to NO_x controls, a lower NO_x level could be achieved. This would increase the likelihood of achieving the Congressional mandate to reduce NO_x emissions. As will be described in the next section, significant reductions in particulate emissions are available from aftertreatment techniques, such as trap-oxidizers. Therefore given (1) that there are other technologies which provide significant particulate reduction and (2) the specificity of the NO_x mandate, EPA has decided that the two Congressional mandates would best be met by reserving the engine-out particulate reductions achievable below 0.41 g/BHP-hr to offset the effects of NO_x control. In this way, the degree of NO_x reduction available to diesels will be enhanced, while significant particulate reductions can still occur via use of trap-oxidizers. Thus, 0.41 g/BHP-hr will be used as the lowest engine-out

[2] See Chapter IV of the Regulatory Analysis for details.

particulate level achievable by all heavy-duty diesels.

While this decision enhances the feasibility of the 1.7 g/BHP-hr NO_x standard it does not insure that net increases in particulate emissions will still not occur due to the implementation of NO_x controls. Any such increases could make the 0.41 g/BHP-hr engine-out particulate level infeasible. To prevent this from occurring, EPA, in its proposals of the NO_x standard will restrict the required NO_x reduction from diesels to that achievable with a 0.41 g/BHP-hr engine-out particulate emission level. In this way, the feasibility of the NO_x standard can be enhanced without affecting the feasibility of the particulate standard being proposed today.

2. Trap-Oxidizers

In addition to reducing particulate emissions formed in the combustion process, additional reductions are available from the application of after-treatment devices, particularly trap-oxidizers. A trap-oxidizer basically consists of a high-temperature trapping material housed in a stainless steel shell. Placed in the exhaust, it collects particulate and periodically (or continually) incinerates (oxidizes) it. The incineration process usually requires an initial minimum exhaust temperature of 450–500° C. Because such temperatures may not normally occur in heavy-duty diesel exhaust, exhaust temperatures may need to be artifically raised to the necessary level to permit regeneration (i.e., incineration).

The particulate collection efficiencies of many trap materials have already been demonstrated. Many materials, such as alumina coated wire mesh and metal wool, have shown efficiencies of up to 65 percent. Slightly modified ceramic monolithic substrates (similar to those used in automotive catalysts) have shown collection efficiencies of up to 84 percent. In determining the technologically achievable level of particulate emissions with aftertreatment, EPA has used a 60 percent initial collection efficiency.[3] This is the same efficiency which EPA used to determine the technologically feasible level for the light-duty diesel particulate standard (45 FR 14496).

Several trap-oxidizer regeneration approaches have been investigated. The simplest solution would be to continuously (or near-continuously) oxidize the particulate, in which case the trap-oxidizer would function much like a diesel catalytic converter. The problem with diesel converters is simply in maintaining the high-temperature conditions that ensure continual oxidation. Much effort is being expended on producing converters which would function on diesels, and designs have been tested by EPA that are close to what is needed. An alternative is to oxidize the particulate only occasionally, when enough organic material has been collected by the trap to aid the process and when the exhaust temperature is high enough to initiate oxidation. Many approaches have been suggested to initiate the oxidation process. The most promising is the addition of an inlet air throttle, which would limit the intake air into the combustion chambers and raise the temperature of the exhaust. The throttling would be periodic, and could be actuated by a combination of the odometer reading and rack position, or might have to be linked to a controller unit coordinating several parameters such as rack position, back-pressure, exhaust gas recirculation, etc. In a study using light-duty diesels, GM reported that over a 1000-mile series of load-up and regeneration tests, utilizing throttling to initiate oxidation, the trap collection efficiency actually increased slightly. There appear to be no technical problems with utilizing throttling to initiate oxidation, and there is evidence that throttling may possibly reduce engine-out particulate and NO_x emissions slightly.

Collection efficiencies and regeneration techniques have progressed to the point where the most critical issue is whether the efficiency and regeneration mechanism can be maintained over the useful life of the vehicle. At this time, EPA has only limited trap-oxidizer durability data, as researchers have been reluctant to fund durability testing until other more basic questions such as burn-off control were solved. The problems of durability are problems which lend themselves to engineering solutions; no major new technology is required. Under controlled conditions, existing traps have already been shown to retain their trapping capability over many burn-off cycles. The trapping media and engine controls already appear to exist for a full useful life trap. The major problem remaining is one of characterizing the in-use operating conditions of the engine, so that regeneration may be controlled to always insure that the burn-off temperature stays below that which could damage the trap. As this is primarily a matter of optimizing the trap position in the exhaust and the logic used by the burn-off control device, we are confident that the durability questions will be resolved in the near future.

One aspect of heavy-duty diesel operaton which might appear to cause a durability problem is a longer useful life (in terms of miles) relative to light-duty diesels. Indeed, the average useful life of a heavy-duty diesel is currently 475,000 miles, while that of a light-duty diesel is only 100,000 miles. In terms of years, however, the average heavy-duty diesel is used only nine years, as opposed to ten years for light-duty diesels. This provides some indication of the difference in the types of driving characteristic of the two types of vehicles. Heavy-duty diesels may accumulate large amounts of mileage, but they also do it in a short period of time under relatively steady conditions. This type of driving should be much less damaging to a trap than the shorter trip driving of a light-duty vehicle, where the temperature transients, which can structurally stress the trap, should be much greater. Thus, the useful lives in terms of time, rather than mileage, should be the better indicator of durability requirements of the trap. As heavy-duty diesel engines capture more of the lighter truck market now dominated by gasoline engines, their operation will begin to approach that of light-duty vehicles in at least some aspects. However, EPA expects the useful life of these former gasoline-fueled vehicles to remain the same after dieselization as before. This useful life is only 114,000 miles, which is very close to that of light-duty diesels. Thus, EPA expects that heavy-duty diesels will experience no greater trap durability problems than light-duty diesels.

EPA recognizes that trap-oxidizers are not currently available to permit compliance with the proposed 1986 heavy-duty diesel standard, but given sufficient good faith effort by the manufacturers, 60 percent efficient trap-oxidizers should be available in time to be incorporated on the 1986 model year fleet. As discussed above, the basic concept of the trap-oxidizer is well understood. The improvements that are necessary are engineering problems, such as trap placement and the optimization of the regeneration control. The solution to these problems is more a function of the resources allocated to the problem than any scientific or technical breakthrough, which would be the case if an entirely new trapping media were required.

The recently promulgated light-duty diesel particulate standards (45 FR 14496) call for a final level of control in 1985 based on trap-oxidizer technology. Information gained from the study of

[3] For further details see the Regulatory Analysis.

trap-oxidizers on light-duty diesels to date has centered on areas such as 1) development of a durable, efficient trapping material, 2) understanding the burn-off process, and 3) development of engine control techniques to ensure proper burn-off. Knowledge gained in these areas should be especially applicable to heavy-duty diesels. However, heavy-duty diesels can often operate under different conditions than their light-duty counterparts. For example, they are at times left to idle for periods of several hours (due to inherent cold-start difficulties and to prevent starter wear). This operating characteristic is important to trap-oxidizer regeneration since exhaust temperatures are very cool at idle; high exhaust temperatures are needed to incinerate collected particulate. Thus, means must be devised to allow for trap-oxidizer regeneration while engines are in this mode. While this problem and others do not appear to be insurmountable they do indicate that some additional design effort will be necessary to incorporate trap-oxidizers onto heavy-duty diesels. To facilitate the application and optimization of these devices onto heavy-duty diesels, an additional year is being provided in this proposal beyond the 1985 date of trap-oxidizer introduction for light-duty diesels.

As mentioned earlier, 1986 is also the year that the forthcoming NO_x proposal will apply for these same engines. Many engine design and operational features of heavy-duty diesels affect both these pollutants (see the Regulatory Analysis for further details). As mentioned earlier, some can cause decreased emissions of one pollutant while causing emission levels of the other to increase. As manufacturers will have to design their engines for particulate control while considering the impact on NO_x emissions (and vice versa) it would be most reasonable to have the two standards apply in the same year, allowing design to occur in parallel. Thus, 1986 appears to be a reasonble date to implement the 0.25 g/BHP-hr particulate standard in light of the design and engineering efforts necessary and because of the close relationship between particulate and NO_x emissions.

Left to the marketplace, it is extremely unlikely that sufficient pressure would be brought to bear on the industry to aggressively pursue trap-oxidizer development. Experience has shown the greatest emission control development work to have taken place when direct regulatory incentives were in place. Since final trap-oxidizer designs are not now available to successfully comply with the proposed 1986 standard, to the extent that the standard motivates the industry to aggressively pursue research and development it is a "technology-forcing" standard. The term "technology-forcing" often implies that the sought-after technology is completely unknown or unforeseeable, but such is not the case here. The basic concept of the trap-oxidizer is very well understood, and, as explained above, much development has already occurred. Thus, this rulemaking is technology forcing only in the respect that it will encourage a feasible control strategy that might otherwise be ignored.

3. Deterioration of Engine and Trap-Oxidizer

Data indicating the degree of deterioration of heavy-duty diesel engines, with regard to particulate emission, over their useful lives are not available since 1) particulate emissions from heavy-duty diesels have not been regulated before and 2) an adequate test procedure has only recently become available; manufacturers will be required to certify using the transient test procedure beginning with the 1985 model year. However, EPA tests of in-use light-duty diesels having accumulated an average 48,000 miles (77,250 kilometers) indicate that little if any increase in engine-out particulate emissions occurs. With the stability of heavy-duty diesel emissions of other pollutants, the use of similar fuel systems, and the similarity of the general emissions stability of light- and heavy-duty diesels, it is reasonable to project that the engine-out particulate emissions of heavy-duty diesels will deteriorate very little. Heavy-duty diesels were not included in this in-use survey since 1) no zero-mile certification data are available because heavy-duty diesel particulate is not currently regulated and 2) the only available test site has been occupied with the baseline emissions program.

Information on the deterioration of trap-oxidizer efficiency is even more scarce, as none are currently commercially available and durability tests of available prototypes have been waiting until after collection and burn-off techniques were perfected. EPA therefore solicits comments in the areas of anticipated engine and particularly trap-oxidizer deterioration as they relate to particulate emissions. For the purposes of this proposed rulemaking EPA has estimated that the combined engine and trap-oxidizer deterioration will be no more than 20 percent.

4. Selective Enforcement Auditing and Production-Line Variability

In addition to complying with EPA's certification process for new engines, heavy-duty diesel manufacturers are also subject to a Selective Enforcement Audit (SEA) of their production engines, the fourth point mentioned above. As is the case for other regulated pollutants, at least 90 percent of a manufacturer's production engines must meet the proposed particulate standard to keep the probability of failing an SEA below 5 percent. This means that manufacturers must achieve excellent quality control or else design their emission control systems to reach levels below the standard on the average. Otherwise, if the control system were designed to just meet the standard, only about half the engines would pass.

To determine how far a manufacturer would have to design below the standard, two factors must be taken into account: 1) the variability of the particulate emissions of the production engines of a given engine family, and 2) the small number of prototypes upon which the design decision is made. The 10 percent acceptable quality level (AQL) could lead manufacturers to design their engines (on the average) to meet a particulate level 1.28 times the existing standard deviation lower than the standard (assuming a normal distribution of emissions) or manufacturers could improve quality control to reduce variability, which would allow them to design closer to the standard.[4] While EPA believes that the production variability of particulate emissions could be reduced from existing levels, the lack of data on the existing variability of production engines, plus the lack of data on the ability to reduce variability, prevents a reliable judgment to be made concerning this ability. The absence of available test facilities also prevents any effort by EPA to obtain such data on its own. Since EPA cannot determine in the case of this regulation that reductions in variability will be sufficient to deal with the effect of a 10 percent AQL, it is reasonable to allow for a reduction in the design target for the average vehicle to account for the presence of a 10 percent AQL. As indicated above, this allowance should be 1.28 times the standard deviation of particulate emissions from production engines. While no actual data on the particulate emission variability of production engines are available, EPA assumed that this variability would be similar to that for gaseous emissions, or 12 percent of

[4] For further details see the Regulatory Analysis.

mean emissions.[5] Given this, the effect of the 10 percent AQL would be to increase the technologically feasible level by 15.4 percent, or a factor of 1.154. Including the effect of basing design decisions on only a small number of prototype engines (assumed to be three in this case) raises this factor to 1.24.

EPA requests data on the actual production line variability of particulate emissions, the degree to which production line variability can be reduced, and also on the methodology used by manufacturers to determine their design targets.

Derivation of Standard: All the above mentioned factors were combined to yield the proposed 0.25 g/BHP-hr standard. First, there is the engine-out particulate level of 0.41 g/BHP-hr which is reduced by 60 percent via trap-oxidizer technology to 0.164 g/BHP-hr. Then, taking into account the effect of emission variability and the 10 percent AQL increases this value by a factor of 1.24 to 0.203 g/BHP-hr. Finally, the deterioration factor is 1.2 increases the technologically feasible level to just under 0.25 g/BHP-hr, which is the level being proposed.

Environmental Impact: The proposed standard will reduce particulate emissions from heavy-duty diesels by 64 percent in 1995 with respect to what would be expected without regulation. Nationwide particulate emissions in 1995 from heavy-duty diesels will be reduced from approximately 218,000-266,000 metric tons per year to 78,000-95,000 metric tons per year. Urban particulate emissions from these vehicles will also decrease 64 percent in 1995 from 79,000-97,000 metric tons per year to 28,000-35,000 metric tons per year. This emission reduction will reduce ambient heavy-duty diesel particulate levels in large cities (e.g., New York, Chicago, Los Angeles) from 1.7–7.2 to 0.6–2.6 micrograms per cubic meter (annual means). Heavy-duty diesel particulate levels in smaller cities (e.g., St. Louis, Pittsburgh, Phoenix) will also decrease from 1.6–4.9 to 0.6–1.8 micrograms per cubic meter (annual means). Localized levels which occur over and above these larger-scale impacts will also decrease from 4.6–5.6 micrograms per cubic meter to 1.6–2.0 micrograms per cubic meter (annual means). These latter impacts could occur as far as 90 meters from very busy roadways.[6]

The above impacts clearly show the significant reductions in ambient particulate emission levels expected from these regulations. It should be noted, however, that not all types of particulate matter have the same level of impact on human health. Small particles, which are much more likely to be deposited in the alveolar region and which require much longer periods of time to be cleared from the respiratory tract, are believed to be much more deleterious to human health on an equal mass basis than larger particles. Thus, control of diesel particulate (100 percent is less than 15 micrometers in diameter and approximately 97 percent is less than 2.5 micrometers in diameter) is especially important with respect to human health. There is also particular concern over the chemical composition of diesel particulate emissions, as the extractable organic fraction of diesel particulate has been shown to be mutagenic in short-term bioassays. EPA is currently performing a health assessment to determine the carcinogenic risk (if any) to human milk. However, EPA has not based the level of the proposed standard on any presumption of a carcinogenic effect being associated with diesel particulate. Should future results from the diesel health effects studies indicate that further action is necessary to control diesel particulate emissions, EPA will exercise its authority under Title II of the Clean Air Act to do so.

Economic Impact (All Costs are In Terms of 1980 Dollars): EPA expects the retail price of heavy-duty diesel vehicles to increase by approximately $527–650 in 1986 due to the engine and vehicle modifications necessitated by this regulation. The retail price increase of a new vehicle mentioned above is about 0.5–3.0 percent of the total cost of a new heavy-duty diesel vehicle. The range of costs is due to possible differences in trap-oxidizer systems which may be used on different models. The trap-oxidizer system is also expected to require maintenance costing about $30 when it is five years old. However, the vehicle modifications involved in adding the trap-oxidizer will eliminate the need to replace the exhaust pipe and muffler throughout the vehicle's life. This will save about $409 in maintenance costs (undiscounted) during the vehicle's life. In all, vehicle maintenance costs should decrease by $178 due to the 1986 standard (discounted to year of vehicle purchase). Overall, then, this regulation will cost $349–472 per vehicle. All of these estimates include profit at both the manufacturer and dealer level. Overall, the increased cost of owning and operating a heavy-duty diesel due to this regulation will be less than 0.3 percent.

Due to past and future increases in the price of gasoline-fueled vehicles due to emission controls and the negligible impact of this regulation on the cost of transporting goods via heavy-duty diesels, EPA expects no decrease in diesel sales relative to the sales of gasoline-fueled vehicles due to aggregate environmental regulation. The aggregate cost of this proposed particulate standard over five years (1986–1990) will be $249–413 million (present value in 1980) or $442–731 million (present value in 1986). Two present value reference points are given because two different conventions have been used in the past; the present (1980) and the year the standard is to be implemented (1986).

Taking all of the above findings into account, the costs of applying the technology necessary to meet the proposed standard appear reasonable. EPA has also examined the impact of this proposal on urban areas and selected communities and no adverse consequences are expected.

Cost Effectiveness: Section 202(a)(3)(A)(iii) of the Clean Air Act does not require EPA to conduct a cost benefit analysis. Nevertheless, EPA has examined the cost effectiveness of the proposed particulate standard. In doing this, EPA examined the traditional methodology used to measure cost effectiveness and modified it slightly. The proposed standard appears consistent with recent EPA actions to control stationary and mobile source particulate emissions which in themselves were cost effective.

The traditional measure of cost effectiveness (dollars per metric ton of particulate controlled) can be made more relevant to health improvements by considering only the inhalable (less than or equal to 15 micrometers in diameter) or fine (less than or equal to 2.5 micrometers in diameter) particulate that is controlled. It is the inhalable and, especially, the fine fractions of suspended particulate which appear to have the greatest potential for adverse health impact. When this is done, the marginal cost-effectiveness ratio for the 1986 heavy-duty diesel particulate standard (effect of trap-oxidizers alone) is $1070–1410 per metric ton of inhalable particulate and $1070–1550 per metric ton of fine particulate (1980 dollars). When any of these bases are used, modified or unmodified, the cost effectiveness of heavy-duty diesel control is found to be consistent with the cost effectiveness of particulate control strategies implemented in the past.

It is important to emphasize that in some respects the mobile and stationary

[5] For further details see the Regulatory Analysis.

[6] Consult the Regulatory Analysis for the methodology followed in determining the air quality impact of heavy-duty diesel particulate emissions.

source strategies for particulate control have certain differences in their primary purposes. Therefore, selection of a measure of effectiveness for comparison purposes has inherent limitations. In spite of these, however, the comparison may still be useful to the degree that it focuses on one of these common purposes, protection of public health and welfare.

There is another step which can be taken to improve the measure of cost effectiveness and that is to relate effectiveness to reductions in ambient pollutant concentrations instead of emission reductions. People's exposure to pollutants is directly related to the ambient pollutant concentration of the air they breathe, but only indirectly related to the emissions from various sources. However, the data necessary to perform such calculations are very difficult to obtain and generally not available. Still, to indicate the potential differences between the air quality impacts of different sources, a rudimentary air quality analysis was performed.[7] Using indicators of a source's impact on air quality relative to its emissions, EPA found that both heavy- and light-duty diesels produce between 45 and 188 times the ambient particulate concentration as the largest power plants (2,920 megawatt heat input) based on equivalent emission rates. Similarly, both heavy- and light-duty diesels produce between 1.1 and 4.7 times the ambient pollutant concentration as smaller power plants (73 megawatt heat input) based on equivalent emission rates. No localized impacts from either source were examined, only large-scale impacts. If localized impacts had been examined, the results might have been different. The results from other stationary sources could also be quite different.

Just considering differences in the relationship between emissions and air quality, the results of any comparison of cost effectiveness could be changed drastically. Indeed, there are many other factors which should also be considered. As mentioned earlier, the above ratios are only an extremely rough estimate of the relative air quality impacts of diesels and power plants. Many simplifications were necessary in order to make this comparison at all. Overall, however, the results also indicate clearly that control of diesel particulate is not less cost effective than other cost-effective control measures adopted by EPA using the measures of effectiveness discussed above.

[7] Consult the Regulatory Analysis for further details.

Alternative Actions: Control of particulate emissions from heavy-duty diesel vehicles is required by the Clean Air Act. Thus, EPA does not have the discretion to forego control of heavy-duty diesel particulate emissions in favor of other control strategies. However, alternative individual engine standards and/or implementation dates for this heavy-duty diesel particulate standard were examined.

The Clean Air requires this particulate standard to "reflect the greatest degree of emission control achievable through the application of technology which the Administrator determines will be available for the model year to which such standards apply." EPA must also give due consideration to cost, energy, and safety. The main goal of our analysis of alternative levels and dates, then, was to determine the level(s) and timing of the standard which best complied with the requirements of the Act.

First, EPA considered implementing a one-step versus a two-step standard. A one-step standard set at the final level of technology (trap-oxidizers) would be available in the same year (1986) as the revised NO_x standards for heavy-duty diesels. As alluded to earlier, manufacturers will be required to certify their engines using the transient test procedure beginning in 1985. This essentially precludes an interim standard earlier than 1985 since it would have to use the 13-mode test procedure, which would not be as representative of in-use particulate emissions as the transient cycle. An interim standard for 1985 would apply for only 1 model year and provide only modest reductions in particulate emissions at a time when no significant increases would be expected, since the NO_x standard would not come into effect until 1986. A standard in 1985 would also divert valuable Agency and industry resources from implementing and meeting the 1986 standards (NO_x and particulate) and shifting them toward a less effective interim particulate standard. In 1986, with the coming of the revised NO_x standard, a particulate standard will be needed to prevent potential increases in particulate emissions. However, by then a standard based on trap-oxidizers could be implemented.

EPA specifically considered a two-step standard with the first standard taking effect in 1986. Under this scenario, the 1986 standard would be based on improved engine design, while the later standard (in this case, 1988) would be based on the use of trap-oxidizers. This alternative would have the advantage of allowing manufacturers more time to develop trap-oxidizers and also separate this work from that related to engine development. Its disadvantages were the added cost of recertifying all engines in 1988 and delaying the primary air quality benefit of the regulation for two more years. EPA also examined the effect of delay on capital and trap-oxidizer costs, but found no substantial advantage resulting from this approach. In all, EPA found that the leadtime advantages of postponing the final level of control did not outweigh the delay of the air quality benefits of a standard which could be implemented in 1986 based on technology and leadtime considerations. This was particularly true given that there appeared to be no great cost benefit involved with delay. For these reasons, EPA chose a one-step standard in 1986. However, EPA would reconsider a two-step standard approach if additional data warranted such action.

Second, EPA considered the possible choices for the level of this standard. These alternative levels have already been discussed in the section on technology and will not be repeated here. In summary, EPA examined the various levels in light of the Clean Air Act requirement that the standard reflect the greatest reduction potential achievable considering the leadtime available and other specified factors and concluded that the standard which is being proposed was appropriate. The issue of cost has already been discussed previously, so no further mention of it will be made here. Since the proposed standard will not affect the fuel economy of heavy-duty diesels, it is reasonable with respect to energy impacts. Based on numerous successful regenerations of prototype trap-oxidizers, EPA also expects that the application of trap-oxidizer technology can and will be made in such a way as to ensure the safe operation of the vehicle.[8] Thus, in consideration of all these factors, we chose the level of 0.25 gram per brake horsepower-hour in 1986 proposed today.

The use of an averaging approach upon which to base the actual particulate standard is not planned for this rulemaking. However, EPA is actively exploring the feasibility of emissions averaging and will be proposing an averaging scheme for controlling NO_x emissions from light- and heavy-duty trucks. The results of this analysis of averaging will in part determine if EPA will consider emissions averaging for this heavy-duty

[8] Consult the Regulatory Analysis for further details.

diesel particulate standard and other existing mobile source emissions standards through future rulemaking actions.

Major Revisions to the Existing Heavy-Duty Test Procedure: The recently promulgated gaseous emissions regulations for 1984 and later model year heavy-duty engines (45 FR 4136) included a new test procedure for determining gaseous exhaust emissions from heavy-duty engines. The test procedure specified for diesel engines was very similar to that specified for gasoline engines and applied to the same gaseous pollutants (HC, CO, NO_x). With the mandate to regulate particulate emissions, EPA has proposed additions to the heavy-duty diesel test procedure to include the measurement of particulate emissions from diesel engines. These additions will not affect the basic heavy-duty test procedure nor the stringency of the test with respect to gaseous emissions, but merely specify the additional equipment and steps necessary for the measurement of diesel particulate.

Because EPA just recently revamped the heavy-duty engine test procedures and foresaw at that time the need to propose these modifications, we took steps then to ensure that no unnecessary equipment expenses would be incurred by manufacturers and others interested in testing diesel engines. The test procedure modifications being proposed today do require certain pieces of equipment to be use which are not required for gaseous emission testing (e.g., the dilution tunnel). To prevent the need for replacing equipment for measuring gaseous emissions which had been used for only a short period of time (e.g., the dilution tunnel replacing the baffle box) with new equipment to allow measurement of particulate emissions, EPA originally designed the gaseous emission test procedure to allow for the addition of equipment associated with particulate testing without making obsolete any of the equipment used for measuring gaseous emissions. In this way, manufacturers could design their transient test cells to allow for future particulate testing, even though the particulate standards had not yet been proposed, and none of their effort would have been wasted.

Additions and changes to the current Federal Test Procedure (FTP) for diesels that would be brought about by the incorporation of particulate testing are discussed below:

(1) The particulate measurement procedure would require a dilution tunnel and a constant mass sampler (i.e., a heated exchanger must precede the critical flow venturi or the positive displacement pump). The dilution tunnel would have to be sufficiently long to assure thorough mixing at the sampling probes. The use of a mixing box with extensive baffling was rejected because of suspected particulate loss on its surfaces. A constant mass sampler, as opposed to a constant volume sampler, is necessary for particulate testing to insure that the particulate sample taken is proportional to the entire emissions of particulate from the engine at any given time.

(2) The total mass of particulate emissions would be measured simultaneously with regulated gaseous emissions over the transient cycle. The particulate matter, after dilution and mixing with ambient air in a dilution tunnel, would be collected on filter media (fluorocarbon or fluorocarbon-coated glass fiber) over both the cold and hot start portions of the test. The temperature of the diluted exhaust at the location of particulate sampling would have to be kept below 125° F (51.7° C) at all times. This could be accomplished by either of two methods, single or double dilution. With single dilution, the constant mass sampler would have to be of sufficient capacity to maintain the temperature of the entire diluted exhaust below 125° F (51.7° C) at the particulate probe tip. With double dilution, the temperature of the diluted exhaust in the primary tunnel would be allowed to be well above 125° F (51.7° C), but a second dilution of a fraction of the exhaust flow in the primary tunnel would have to maintain the temperature of this smaller sample below 125° F (51.7° C) at all times during the test.

This 125° F (51.7° C) temperature restriction is necessary to insure that heavy hydrocarbons and other organic compounds, which would become associated with the particles upon ambient dilution in real life, are also measured by EPA's test procedure. This temperature requirement also causes some of these heavy organics to be measured twice, once as particulate and once as hydrocarbons. Before the level of exhaust hydrocarbons is measured under EPA's test procedure, the sample is heated to 375° F (191° C) to drive some of these hydrocarbons off of the particulate. These hydrocarbons on the particulate at 125° F (51.7° C) and in the gaseous phase at 375° F (191° C) may participate in oxidant-forming reactions and therefore should be measured as hydrocarbons. These same hydrocarbons may also remain on the particulate and be inhaled as such and therefore should also be measured as particulate.

As can be seen from an examination of the test procedure amendments being proposed today, EPA has republished the entire Subpart N, which contains the transient test procedure for heavy-duty vehicles, gasoline-fueled and diesel, for the 1980 model year. We did this for a number of reasons. One, we hoped that this would provide the user with a single, comprehensive document containing the heavy-duty test procedure for both gaseous and particulate emissions. This would avoid the need to piece this proposal together with past publications in order to obtain a complete test procedure. Two, while the number of substantive changes to the test procedure is limited, the large amount of internal referencing done in Subpart N for descriptive purposes (e.g., see 86.1310–84) requires many sections to be revised because the references will change (to "–86"). Thus, the majority of the sections in Subpart N would have needed to be revised regardless.

While the republication of Subpart N for the 1986 model year makes it easier to use the test procedure in practice, it also makes it more difficult to identify the revisions being proposed today. To aid those interested in finding these revisions, EPA has listed below the sections of Subpart N which contain proposed substantive revisions. Any revisions contained in other sections should only be revised references or the addition of "particulate" to descriptive sentences which currently describe the test procedure as applying only to the measurement of gaseous emissions.

Sections in Subpart N containing proposed substantive revisions are:

§ 86.1308–86
§ 86.1310–86
§ 86.1312–86
§ 86.1320–86
§ 86.1327–86
§ 86.1337–86
§ 86.1339–86
§ 86.1342–86
§ 86.1344–86

Test Procedure Alternatives: EPA considered and rejected two alternative techniques for estimating on-the-road particulate emissions. The first was smoke measurement. EPA rejected this technique because 1) smoke does not correlate well with particulate emissions across engine lines and 2) smoke measurements are very inaccurate at the levels encountered over most of the transient cycle.

In spite of this, the presence of the smoke standard has helped to prevent particulate emissions from increasing while no particulate standards were in effect. There is some correlation between smoke and particulate and a worst case test always has some effect on other-than-worst-case conditions. However, a smoke standard is not a viable long-term alternative to a particulate emission standard.

The existing smoke test and standard are being retained along with the addition of particulate testing. The smoke test measures smoke under worst case conditions which are not often encountered over the transient cycle. Therefore, it is unlikely that the particulate standard alone would insure continued compliance with the existing smoke standards. Also, the current smoke standard exists primarily for aesthetic reasons which do not disappear with the addition of particulate testing.

The second technique EPA considered was opti-acoustical measurement. This technique uses a laser beam to heat the particles in the exhaust and measures the resulting pressure waves with a spectrophone. EPA also rejected this technique because (1) it is as yet unproven and (2) it appears to have many of the same correlation problems as smoke measurement, primarily that the acoustical response varies with the chemical composition of the particulate.

Changes from Previous Draft Test Procedure: EPA published the "Draft Recommended Practice for Measurement of Gaseous and Particulate Emissions from Heavy-Duty Diesel Engines Under Transient Conditions" in April 1979 and distributed it on May 8, 1979. Two manufacturers—Caterpillar Tractor Company and Cummins Engine Company—responded to the request for comments on the Draft Recommended Practice. One of the more significant responses was Cummins' comment that substantial errors in the instantaneous proportionality of the sample taken from the primary tunnel (up to 25 percent) might result with the double-dilution sampling technique due to the two second residence time in the secondary tunnel. The effect of such an error on particulate measurements would depend on the particle concentrations at the times the sampling errors occurred. However, these instantaneous concentrations cannot be measured at this time.

In its studies of the two systems to date, EPA has found no evidence that any such sampling error actually affects the mass of particulate collected. Rather, the evidence indicated that the two systems produced very comparable results. However, EPA made one modification to the draft recommended practice which should substantially reduce any instantaneous sampling errors and further ensure that no such errors would affect the mass of particulate collected. EPA has reduced the required residence time of the diluted exhaust in the secondary tunnel from 2 to 0.25 seconds. The latter residence time was derived from confirmable light-duty diesel testing using the single dilution technique. It represents the total time necessary after dilution to ensure that the gaseous and particulate phases come to equilibrium before the particulate is collected.

The remainder of the comments from both manufacturers related to very detailed aspects of the test procedure. EPA has incorporated these comments, where possible, into the test procedure being proposed today. Some suggested revisions were not made, however, due to the fact that no data were presented to support the viability of the revision. A detailed analysis of the comments is contained in the docket and can also be obtained by calling or writing the contact person for this regulation (shown above).

Selective Enforcement Auditing (SEA): SEA will be performed on production heavy-duty diesel engines beginning in the 1984 model year to determine whether they conform to the regulations under which their respective certificates of conformity were issued. Subpart K of Part 86, SEA of New Gasoline-Fueled and Diesel Heavy-Duty Engines (45 FR 4136, Jan. 21, 1980), describes the program for the testing of these engines. Paragraph § 86.1008–84(a) of Subpart K provides that these engines will be tested in accordance with Subpart N. With the establishment of a new particulate emission standard and the addition of particulate testing procedures to Subpart N, EPA would require SEA testing of heavy-duty diesel engines for compliance with this standard beginning in the 1986 model year.

Nonconformance Penalties: Section 206(g) of the Clean Air Act provides for nonconformance penalties (NCPs) ". . . in the case of any class or category of heavy-duty vehicles or engines to which a standard promulgated under section 202(a) of this Act applies. . . ." As discussed elsewhere in this preamble, EPA believes that all heavy-duty diesel engines will be capable of complying with the proposed standard. However, whenever a manufacturer must do substantial development work and/or make substantial modifications of existing emission control techniques in order to both certify and produce heavy-duty diesel engines capable of complying with all regulatory requirements, there is some risk that unforeseen circumstances could result in "technological laggards," i.e., manufacturers whose heavy-duty diesel engines are incapable of complying with the regulation. Therefore, the heavy-duty diesel engines affected by this regulation may be subject to NCPs.

The proposed particulate emission standard for heavy-duty diesel engines is partially based on the application of trap-oxidizer exhaust treatment devices. As discussed in the "Technology" section, the basic trap-oxidizer concept is well understood. However, these devices are not currently available to permit compliance with the proposed standard; various engineering improvements still have to be made. Therefore, trap-oxidizers represent a basically new emission control technique for which substantial development work for heavy-duty diesel engines usage is still required. Manufacturers may experience unforeseen problems in the development and application of successful trap-oxidizers, and it is for this reason that EPA intends to make NCPs available for heavy-duty diesel particulate emissions.

The Agency is not proposing the specific penalty rate or the "upper limit" on allowable particulate emissions in this NPRM. These will be proposed at a later date thorugh separate rulemaking, with full opportunity for public comment. EPA's intention to offer NCPs does not affect leadtime considerations for meeting the proposed particulate standard. The availability of NCPs should not be viewed as a mechanism allowing manufacturers to design to a higher emission standard, but rather as a "safety valve" for those who have made good faith efforts, but are experiencing unforeseen problems in compliance. EPA intends to structure the NCPs, as required by the Act, to remove any competitive disadvantage to manufacturers complying with the standard. The penalty will also increase periodically to provide a further incentive to bring nonconforming engines into compliance or to develop new replacement engines as expeditiously as possible.

Evaluation Plan: EPA intends to review the effectiveness and need for continuation of the provisions contained in this action no more than five years after initial implementation of the final regulation. In particular, EPA will solicit comments from affected parties with regard to cost and other burdens associated with compliance and will also review data on the particulate emissions from heavy-duty diesel vehicles built before and after promulgation of the regulation to determine how effective this measure has been.

Reporting and Recordkeeping Requirements: This regulation does not require any new significant reporting or recordkeeping burden. However, it does

add particulate matter to the list of exhaust pollutants which are currently regulated from heavy-duty diesels. As such it will have some impact on the current load of reporting and recordkeeping requirements. Specifically, it will require: 1) submission of the design of all new emission control systems added solely for the purpose of particulate control as part of the manufacturer's application for certification: and 2) inclusion of the rate of particulate emission from affected vehicles along with other test results. Both of these additions are quite minor when compared to the current reporting requirements. Detailed designs of the diesel engine are already required and the only device likely to come under 1) above is the trap-oxidizer. Similarly, results from gaseous emission tests are already required and this regulation will only require the addition of a few numbers to whole pages of values.

Given that the reporting requirements of this regulation only involve minor additions to existing requirements, EPA does not find it reasonable to automatically delete these requirements if affirmative action is not taken within five years. Rather, EPA believes that it is in the public's best interest to perform a review of the reporting requirements of this regulation along with the review of all of the reporting requirements of mobile source air pollution regulation. This review of reporting requirements will be part of an overall review of the regulations themselves which will take place within the next five years.

Note.—The Administrator has determined that this action is a "Significant" regulation. We have prepared a document entitled "Heavy-Duty Diesel Particulate Regulations: Regulatory Analysis" detailing the Regulatory Analysis and other analyses required by Executive Order 12044 and the Economic Impact Assessment required by Section 317 of the amended Clean Air Act. Anyone may review and reproduce this document in the EPA Central Docket Section. Copies are also available upon request.

Dated: December 23, 1980.

Douglas M. Costle,

Administrator.

EPA proposes to amend Subparts A and N of 40 CFR Part 86 as set forth below:

1. Section 86.086-11 is revised to read as follows:

§ 86.086–11 Emission standards for 1986 and later model year diesel heavy-duty engines.

(a)(1) Exhaust emissions from new 1986 and later model year diesel heavy-duty engines shall not exceed the following:

(i) *Hydrocarbons.* 1.3 grams per brake horsepower hour, as measured under transient operating conditions (Subpart N).

(ii) *Carbon monoxide.* 15.5 grams per brake horsepower hour as measured under transient operating conditions (Subpart N).

(iii) *Oxides of nitrogen.* 10.7 grams per brake horsepower hour, as measured under transient operating conditions (Subpart N).

(iv) *Particulate matter.* 0.25 grams per brake horepower hour, as measured under transient operating conditions (Subpart N).

(2) The standards set forth in paragraph (a)(1) of this section refer to the exhaust emissions generated over operating schedules as set forth in Subpart N and measured and calculated in accordance with those procedures.

(b)(1) The opacity of smoke emissions from new 1986 and later model year diesel heavy-duty engines shall not exceed:

(i) 20 percent during the engine acceleration mode.

(ii) 15 percent during the engine lugging mode.

(iii) 50 percent during the peaks in either mode.

(2) The standards set forth in paragraph (b)(1) of this section refer to exhaust smoke emissions generated under the conditions set forth in Subpart I of this part and measured and calculated in accordance with those procedures.

(c) No crankcase emissions shall be discharged into the ambient atmosphere from any new 1986 model year naturally-aspirated diesel heavy-duty engine. This provision does not apply to turbocharged engines.

(d) Every manufacturer of new motor vehicle engines subject to the standards prescribed in this section shall, prior to taking any of the actions specified in section 203(a)(1) of the Act, test or cause to be tested motor vehicle engines in accordance with applicable procedures in Subparts I or N of this part to ascertain that such test engines meet the requirements of paragraphs (a), (b) and (c) of this section.

2. A new § 86.086–28 is proposed to read as follows:

§ 86.086–28 Compliance with emission standards.

(a)(1) Paragraph (a) of this section applies to light-duty vehicles.

(2) The applicable exhaust and fuel evaporative emission standards of this subpart apply to the emissions of vehicles for their useful life.

(3) Since it is expected that emission control efficiency will change with mileage accumulation on the vehicle, the emission level of a vehicle which has accumulated 50,000 miles will be used as the basis for determining compliance with the standards.

(4) The procedure for determining compliance of a new motor vehicle with exhaust emission standards is as follows:

(i) Separate emission deterioration factors shall be determined from the exhaust emission results of the durability-data vehicle(s) for each engine-system combination. A separate factor shall be established for exhaust HC, exhaust CO, exhaust NOx, and exhaust particulate (diesel vehicles only) for each engine-system combination. A separate evaporative emission deterioration factor shall be determined for each evaporative emission family-evaporative emission control system combination from the testing conducted by the manufacturer (gasoline-fueled vehicles only).

(A) The applicable results to be used in determining the exhaust emission deterioration factors for each engine-system combination shall be:

(*1*) All valid exhaust emission data from the tests required under § 86.086–26(a)(4) except the zero-mile tests. This shall include the official test results, as determined in § 86.084–29 for all tests conducted on all durability-data vehicles of the combination selected under § 86.086–24(c) (including all vehicles elected to be operated by the manufacturer under § 86.086–24(c)(1)(ii)).

(*2*) All exhaust emission data from the tests conducted before and after the scheduled maintenance provided in § 86.086–25.

(*3*) All exhaust emission data from tests required by maintenance approved under § 86.086–25, in those cases where the Administrator conditioned his approval for the performance of such maintenance on the inclusion of such data in the deterioration factor calculation.

(B) All applicable exhaust emission results shall be plotted as a function of the mileage on the system, rounded to the nearest mile, and the best fit straight lines, fitted by the method of least squares, shall be drawn through all these data points. The interpolated 4,000- and 50,000-mile points on this line must be within the low-altitude standards provided in § 86.085–8 or § 86.085–9, as applicable, or the data will not be acceptable for use in calculation of a deterioration factor, unless no applicable data point exceeded the standard. An exhaust emission deterioration factor shall be calculated for each engine-system combination as follows:

Factor = Exhaust emissions interpolated to 50,000 miles divided by exhaust emissions interpolated to 4,000 miles.

These interpolated values shall be carried out to a minimum of four places to the right of the decimal point before dividing one by the other to determine the deterioration factor. The results shall be rounded to three places to the right of the decimal point in accordance with ASTM E 29–67.

(C) An evaporative emissions deterioration factor (gasoline-fueled vehicles only) shall be determined from the testing conducted as described in § 86.086–21(g)(4)(i), for each evaporative emission family-evaporative emission control system combination to indicate the evaporative emission level at 50,000 miles relative to the evaporative emission level at 4,000 miles as follows:

Factor = Evaporative emission level at 50,000 miles minus the evaporative emission level at 4,000 miles.

The factor shall be established to a minimum of two places to the right of the decimal.

(ii)(A) The official exhaust-emission test results for each emission-data vehicle at the 4,000-mile test point shall be multiplied by the appropriate deterioration factor: *Provided;* That if a deterioration factor as computed in paragraph (a)(4)(i)(B) of this section is less than one, that deterioration factor shall be one for the purposes of this paragraph.

(B) The official evaporative emission test results (gasoline-fueled vehicles only) for each evaporative emission-data vehicle at the 4,000-mile test point shall be adjusted by addition of the appropriate deterioration factor: *Provided;* That if a deterioration factor as computed in paragraph (a)(4)(i)(C) of this section is less than zero, that deterioration factor shall be zero for the purposes of this paragraph.

(iii) The emissions to compare with the standard shall be the adjusted emissions of paragraphs (a)(4)(ii) (A) and (B) of this section for each emission-data vehicle. Before any emission value is compared with the standard, it shall be rounded, in accordance with ASTM E 29–67, to two significant figures. The rounded emission values may not exceed the standard.

(iv) Every test vehicle of an engine family must comply with the exhaust emission standards, as determined in paragraph (a)(4)(iii) of this section, before any vehicle in that family may be certified.

(v) Every test vehicle of an evaporative emission family must comply with the evaporative emission standard, as determined in paragraph (a)(4)(iii) of this section before any vehicle in that family may be certified.

(b)(1) Paragraph (b) of this section applies to light-duty trucks and heavy-duty engines.

(2) The exhaust and fuel evaporative emission standards of § 86.085–9, § 86.086–10, and § 86.086–11, as appropriate, apply to the emissions of vehicles or engines for their useful life.

(3) Since emission control efficiency generally decreases with the accumulation of mileage on the vehicle or engine, deterioration factors will be used in combination with emission-data test results as the basis for determining compliance with the standards.

(4)(i) Paragraph (b)(4) of this section describes the procedure for determining compliance of a new vehicle or engine with exhaust emission standards, based on preliminary deterioration factors supplied by the manufacturer. The procedure described here shall be used for the first model year for which the manufacturer applies for a certificate of conformity with the applicable emission standards for an engine family-control system combination, and for the second model year as well if the criteria of §§ 86.086–26 (b)(3) and (c)(3) are met.

(ii) Separate preliminary exhaust emission deterioration factors, determined from tests of vehicles, engines, subsystems, or components conducted by the manufacturer, shall be supplied for each engine-system combination. Separate factors shall be established for transient HC, CO, and NOx, idle CO (gasoline vehicles and engines only), and exhaust particulate (diesel light-duty trucks and diesel heavy-duty engines only). For heavy-duty diesel engines, separate factors shall also be established for the acceleration mode (designated as "A"), the lugging mode (designated as "B"), and the peak opacity (designated as "C").

(iii)(A) For transient HC, CO, and NO_x, idle CO (gasoline vehicles and engines only), and exhaust particulate (diesel light-duty trucks and diesel heavy-duty engines only), the official exhaust emission results for each emission-data vehicle at the 4,000-mile test point, or for each emission-data engine at the 125 hours test point, shall be adjusted by multiplication by the appropriate deterioration factors. However, if the deterioration factors supplied by the manufacturer is less than one, it shall be one for the purposes of this paragraph.

(B) acceleration smoke ("A"), lugging smoke ("B"), and peak smoke ("C"), the official exhaust emission results for each emission-data engine at the 125-hour test point shall be adjusted by the addition of the appropriate deterioration factor. However, if the deterioration factor supplied by the manufacturer is less than zero, it shall be zero for the purposes of this paragraph.

(iv) The emission values to compare with the standards shall be the adjusted emission values of paragraph (b)(4)(iii) of this section rounded to two significant figures in accordance with ASTM E 29–67 for each emission-data vehicle or engine.

(5)(i) Paragraph (b)(5) of this section describes the procedure for determining compliance of a new vehicle or engine with exhaust emission standards, based upon partial or full results of in-use mileage accumulation.

(ii) Separate emission deterioration factors shall be determined from the emission results collected to date from the durability-data vehicles or engines in each engine-system combinations. Separate factors shall be established for transient HC, CO, and NOx, idle CO (gasoline vehicles and engines only), and exhaust particulate (diesel light-duty trucks and diesel heavy-duty engines only). For heavy-duty diesel engines, separate factors for smoke shall also be established for the acceleration mode (designated as "A"), the lugging mode (designated as "B"), and the peak opacity (designated as "C").

(A) The applicable results to be used in determining the deterioration factors for each combination shall be:

(*1*) The results of the emission tests conducted on light-duty trucks durability-data vehicles after accumulating 4,000-mile according to the Durability Driving Schedule, or on heavy-duty durability-data engine after accumulating 125 hours manufacturer's dynamometer service accumulation schedule. The mileage point for these results shall be taken to be 4,000 miles for the purpose of this section.

(*2*) The results of all emission tests conducted on durability-date vehicles and engines during in-use mileage accumulation, as required or permitted by § 86.086–26(b)(5)(v) (light-duty trucks) or § 86.086–26(c)(5)(v) (heavy-duty engines), except those excluded under § 86.086–25(b)(1)(xi) or § 86.086–26(b)(5)(vii) for light-duty trucks, or § 86.086–25(b)(1)(xi) or § 86.086–26(c)(5)(vii) for heavy-duty engines. The mileage points for heavy-duty engine results shall be adjusted by the addition of 4,000 miles at the time of deterioration factor calculation.

(B) All applicable exhaust emission results shall be plotted as a function of accumulated in-use mileage. Separate plots shall be made for each durability data vehicle or engine. All least squares regression lines plus high mileage values

and low mileage values resulting from the procedures of paragraph (b)(5) shall be shown on these plots.

(C)(*1*) Deterioration factors for each vehicle or engine for transient HC, CO, and NOx, for idle CO (gasoline-fueled vehicles and engines only), and exhaust particulate (light-duty diesel trucks and heavy-duty diesel engines only) shall be calculated by dividing the high mileage value of paragraph (b)(5)(ii)(E) by the low mileage value of paragraph (b)(5)(ii)(D). A factor less than one shall be set equal to one.

(*2*) Deterioration factors for each heavy-duty diesel engine for acceleration smoke ("A"), lugging smoke ("B"), and peak smoke ("C"), shall be calculated by subtracting the low mileage value of paragraph (b)(5)(ii)(D) from the high mileage value of paragraph (b)(5)(ii)(E). A negative factor shall be set equal to zero.

(D) The low mileage value shall be based upon all applicable data for mileage prior to the actual change point for any external aftertreatment device (e.g., catalyst or particulate trap-oxidizers). The best fit straight line shall be fitted to this data by the method of least squares. The low mileage values shall be the value of this line interpolated to the 4,000-mile point.

(E) The high mileage value shall be calculated as follows:

(*1*) Prior to the actual change for any external aftertreatment device, the high mileage value shall be the larger of the values resulting from the following two methods.

(*i*) The best fit straight line fitted by the method of least squares to the applicable data and extrapolated (or interpolated if the in-use mileage accumulation is complete) to the high mileage point. The high mileage point shall be either the useful life or a mileage which represents a point 50 percent of the useful life past the current mileage, whichever is smaller.

(*ii*) The highest of any data points (or average of results if the manufacturer conducted multiple tests at each point) which exceed two standard errors of the estimate from the best fit straight line fitted by the method of least squares to the applicable data.

(*2*) After the actual change of any external aftertreatment device, in the case where only one applicable mileage test point exists after the change, the value (or average of values) shall be compared to the value of the best fit straight line of paragraph (b)(5)(ii)(D) extrapolated to that mileage. If the value (or average of values) falls below the line it shall not be used in the calculations, and the high mileage value shall be as determined in subparagraph (*1*) above. If the value (or average of values) falls on or above the line, the data for the test point after the change of the external aftertreatment device shall be added to the data used in subparagraph (*1*) above and the high mileage value recomputed by the procedure of subparagraph (*1*). In this case, the low mileage value of paragraph (b)(5)(ii)(D) shall also be recalculated based upon inclusion of the additional data.

(*3*) After the actual change of any external aftertreatment device, in the case where two or more applicable data shall be divided into two sets. The first set shall include all data for mileage points prior to the change point. The second set shall include all data for mileage points after the change point. The procedure of subsection (*1*) above shall be performed separately for each set of data. The actual high mileage value shall be that from whichever data set yields the higher value.

(F) The single in-use deterioration factor for each engine family-control system combination for each of transient HC, CO, and NO_x, idle CO (gasoline vehicles and engines only), exhaust particulates (diesel light-duty trucks and diesel heavy-duty engines only) and the acceleration, lugging, and peak capacity smoke modes (heavy-duty diesel engines), shall be the arithmetic mean of the corresponding factors for each engine as determined in paragraph (b)(5)(ii)(C) of this section.

(iii)(A) For transient HC, CO, and NO_x, idle CO (gasoline vehicles and engines only), and exhaust particulate (diesel light-duty trucks and diesel Heavy-duty engines only), the official exhaust emission results for each emission-data vehicle or engine at the 4,000-mile or 125 hour test point shall be adjusted by multiplication by the appropriate deterioration factor.

(B) For acceleration smoke ("A"), lugging smoke ("B"), and peak smoke ("C"), the official exhaust emission results for each emission-data engine at the 125-hour test point shall be adjusted by the addition of the appropriate deterioriation factor.

(iv) The emission values to compare with the standards shall be the adjusted emission values of paragraph (b)(4)(iii) of this section rounded to two significant figures in accordance with ASTM E 29–67 for each emission-data vehicle or engine.

(6)(i) Paragraph (b)(6) of this section describes the procedure for determining compliance of a new light-duty truck with fuel evaporative emission standards. The procedure described here shall be used for all vehicles in all model years.

(ii) The manufacturer shall determine, based on testing described in § 86.086–21(b)(4)(ii), and supply an evaporative emission deterioration factor for each evaporative emission family-evaporative emission control system combination. The factor shall be calculated by subtracting the emission level at 4,000 miles from the emission level at the useful life point.

(iii) The official evaporative emission test results for each evaporative emission-data vehicle at the 4,000-mile test point shall be adjusted by the addition of the appropriate deterioration factor. However, if the deterioration factor supplied by the manufacturer is less than zero, it shall be zero for the purposes of this paragraph.

(iv) The emission value to compare with the standards shall be the adjusted emission value of paragraph (b)(6)(iii) of this section rounded to two significant figures in accordance with ASTM E 29–67 for each evaporative emission-data vehicle.

(7) Every test vehicle or engine of an engine family must comply with all applicable standards, as determined in paragraph (b)(4)(iv) or (b)(5)(iv) and paragraph (b)(6) of this section, before any vehicle or engine in that family will be certified.

(C) [Reserved]

(2)–(6) [Reserved]

3. The following sections are added to the table of contents under Subpart N.

Subpart N—Emission Regulations for New Gasoline-Fueled and Diesel Heavy-Duty Engines; Gaseous and Particulate (Diesels Only) Exhaust Test Procedures

* * * * *

Sec.

86.1301–86 Scope; applicability.
86.1302–86 Definitions.
86.1303–86 Abbreviations.
86.1304–86 Section numbering; construction.
86.1305–86 Introduction; structure of subpart.
86.1306–86 Equipment required and specifications; overview.
86.1307–86 [Reserved]
86.1308–86 Dynamometer and engine equipment specifications.
86.1309–86 Exhaust gas sampling system; gasoline-fueled engines.
86.1310–86 Exhaust gas sampling and analytical system; diesel engines.
86.1311–86 Exhaust gas analytical system; CVS bag sample.
86.1312–86 Weighing chamber (or room) and microgram balance specifications.
86.1313–86 Fuel specifications.
86.1314–86 Analytical gases.
86.1315–86 [Reserved]
86.1316–86 Calibrations; frequency and overview.
86.1317–86 [Reserved]

86.1318–86 Engine dynamometer calibrations.
86.1319–86 CVS calibration.
86.1320–86 Gas meter or flow instrumentation calibration, particulate measurement.
86.1321–86 Hydrocarbon analyzer calibration.
86.1322–86 Carbon monoxide analyzer calibration.
86.1323–86 Oxides of nitrogen analyzer calibration.
86.1324–86 Carbon dioxide analyzer calibration.
86.1325–86 [Reserved]
86.1326–86 Calibration of other equipment.
86.1327–86 Engine dynamometer test procedures; overview.
86.1328–86 [Reserved]
86.1329–86 [Reserved]
86.1330–86 Test sequence; general requirements.
86.1331–86 [Reserved]
86.1332–86 Engine map procedures.
86.1333–86 Transient test cycle generation.
86.1334–86 Pre-test engine and dynamometer preparation.
86.1335–86 Optional forced engine cool-down procedure.
86.1336–86 Engine starting and restarting.
86.1337–86 Engine dynamometer test run.
86.1338–86 Emission measurement accuracy.
86.1339–86 Diesel particulate filter handling and weighing.
86.1340–86 Exhaust sample analysis.
86.1341–86 Test cycle validation criteria.
86.1342–86 Calculations; exhaust emissions.
86.1343–86 [Reserved]
86.1344–86 Information required.

Subpart N—Emission Regulations for New Gasoline-Fueled and Diesel Heavy-Duty Engines; Gaseous and Particulate (Diesels Only) Exhaust Test Procedures

4. A new § 86.1301–86 is added and reads as follows:

§ 86.1301–86 Scope; applicability.

This subpart contains gaseous emission test procedures for gasoline-fueled and the gaseous and particulate emission test procedure for heavy-duty diesel engines. It applies to 1986 and late model years.

5. A new § 86.1302–86 is added and reads as follows:

§ 86.1302–86 Definitions.

The definitions in § 86.084–2 apply to this subpart.

6. A new § 86.1303–86 is added and reads as follows:

§ 86.1303–86 Abbreviations.

The abbreviations in § 86.084–3 apply to this subpart.

7. A new § 86.1304–86 is added and reads as follows:

§ 86.1304–86 Section numbering; construction.

(a) The model year of initial applicablity is indicated by the section number. The two digits following the hyphen designate the first model year for which a section is effective. A section remains effective until superseded.

Example: Section § 86.1311–86 applies to the 1986 and subsequent model years until superseded. If a section § 86.1311–88 is promulgated it would take effect beginning with the 1988 model year; § 86.1311–86 would apply to model years 1986 through 1987.

(b) A section reference without a model year suffix refers to the section applicable for the appropriate model year.

(c) Unless indicated, all provisions in this subpart apply to both gasoline-fueled and diesel heavy-duty engines.

8. A new § 86.1305–86 is added and reads as follows:

§ 8.1305–86 Introduction; structure of subpart.

(a) This subpart describes the equipment required and the procedures to follow in order to perform exhaust emission tests on gasoline-fueled and diesel heavy-duty engines. Subpart A sets forth the testing requirements and test intervals necessary to comply with EPA certification procedures.

(b) Four topics are addressed in this subpart. Sections 86.1306–86 through 86.1315–86 set forth specifications and equipment requirements; §§ 86.1316–86 through 86.1326–86 discuss calibration methods and frequency; test procedures are listed in §§ 86.1327–86 through 86.1341–86; calculation formulas are found in § 86.1342–86; data requirements are found in § 86.1344–86.

9. A new § 86.1306–86 is added and reads as follows:

§ 86.1306–86 Equipment required and specifications; overview.

This subpart contains procedures for exhaust emissions tests on diesel or gasoline-fueled heavy-duty engines. Equipment required and specifications are as follows:

(a) *Exhaust emission tests.* All engines subject to this subpart are tested for exhaust emissions. Diesel and gasoline-fueled engines are tested identically with the exception of hydrocarbon measurements; diesel engines require a heated hydrocarbon detector, § 86.1310–86. Necessary equipment and specifications appear in sections 86.1308–86 through 86.1311–86.

(b) *Fuel, analytical gas, and engine cycle specifications.* Fuel specifications for exhaust emission testing are specified in § 86.1313–86. Analytical gases are specified in § 86.3414–86. The EPA heavy-duty transient engines cycles for use in exhaust testing are described in § 86.1333–86 and specified in Appendix I.

10. A new § 86.1307–86 is added and reads as follows:

§ 86.1307–86 [Reserved]

11. A new § 86.1308–86 is added and reads as follows:

§ 86.1308–86 Dynamometer and engine equipment specifications.

(a) *Engine dynamometer.* The engine dynamometer system must be capable of controlling engine torque and rpm simultaneously over transient cycles. The transient torque and rpm schedules described in § 86.1333–86 and specified Appendix I (f and g) must be followed within the accuracy requirements specified in § 86.1341–86. In addition to these general requirements, the dynamometer read out and read out signals for speed and torque shall meet the following accuracy specifications:

(1) Engine speed shall be accurate to within 2 percent of point at all speeds.

(2) Engine torque at the flywheel shall be accurate to within 3 percent of point at all torque settings above 10 percent of full-scale of the torque measuring device. Below 10 percent of full-scale, the torque measuring device shall have an accuracy of:

(1) ±2.5 ft.-lbs., if the full scale value is 550 ft.-lbs. or less.

(ii) ±5 ft.-lbs., if the full scale value is 1050 ft.-lbs. or less.

(iii) ±10 ft.-lbs., if the full scale value is greater than 1050 ft.-lbs.

(3) *Option:* Internal dynamomter signals (i.e., armature current, etc.) may be used for torque measurement provided that it can be shown that the true engine flywheel torque during the test cycle conforms to the test cycle values as specified in § 86.1333–86, and if the technique is approved in advance by the Administrator. The minimum requirement for the Administrator's approval would include compensation for increased or decreased flywheel torque due to the armature inertia during accelerations and decelerations in the test cycle. Engineering data and comparison test results may be required.

(b) *Cycle verification equipment.* In order to verify that the test engine has followed the test cycle correctly, the dynamometer read out signals for speed and torque must be collected in a manner that allows a statistical correlation between the actual engine performance and the test cycle (See § 86.1341–86). Normally this collection process would involve conversion of analog dynamometer signals into digital values for storage in a computer. The conversion of dynamometer read out values into values (computer or other)

that are used to evaluate the validity of engine performance in relation to the test cycle shall be performed in a manner such that:

(1) Speed values used for cycle evaluation are accurate to within 2 percent of the dynamometer speed read out value.

(2) Engine flywheel torque values used for cycle evaluation are accurate to within 3 percent of the dynamometer torque read out value.

(c) *Option:* For some systems it may be more convenient to combine the tolerances in paragraphs (a) and (b). This is permitted if the root mean square method (RMS) is used. The RMS values would then refer to accuracy in relationship to true value.

(1) Speed values used for cycle evaluation shall be accurate to within 2.8 percent of true value.

(2) Engine flywheel torque value used for cycle evaluation shall be accurate to within 4.2 percent of true value.

(d) *Speed calibration equipment.* A 60-tooth (or greater) wheel in combination with a common mode rejection frequency counter is considered an absolute standard for engine or dynamometer speed.

(e) *Torque calibration equipment.* Two techniques are allowed for torque calibration. Alternate techniques may be used if shown to be equivalent, and if prior approval is obtained from the Administrator.

(1) The lever-arm dead-weight technique involves the placement of known weights a known distance from the center of rotation of the torque measuring device. The equipment required is:

(i) *Calibration weights.* A minimum of 6 calibration weights for each range of torque measuring device used are required. The weights must be approximately equally spaced and each must be accurate to 0.5 percent of National Bureau of Standard weights. Laboratories located in foreign countries may certify calibration weights to local government bureau standards. Certification of weight accuracy by state government Bureau of Weights and Measures is acceptable. Effects of changes in gravitational constant at the test site may be accounted for if desired.

(ii) A lever arm with a minimum length of 24 inches. The distance from the center of the engine torque measurement device to the point of weight application shall be accurate to within 0.010 inches. The arm must be balanced or the hanging torque of the arm must be known within ±0.1 ft.-lbs.

(2) The transfer technique involves the use of a master load cell with a method of loading (usually hydraulic) the torque measuring device, or master unit that applies a known force to the torque measuring device based on piston area and pressure. The equipment required is:

(i) A master load cell or force application unit that must be calibrated at each test weight specified in paragraph (e)(1)(i) of this section with known weights traceable to within 0.1 percent of NBS weights. The provision on traceability in (e)(1)(i) apply to this section. The overall accuracy of the calibration curve of torque applied to the engine torque sensor as determined by the master units shall be within 0.5 percent of true value. Below 10 percent of full scale of the master unit the calibration curve of torque applied to the engine torque sensor shall be accurate to:

(A) ±0.5 ft.-lbs. of true value if full scale value is 550 ft.-lbs. or less.

(B) ±1.0 ft.-lbs. of true value if full scale value is 1050 ft.-lbs. or less.

(C) ±2.0 ft.-lbs. of true value if full scale value is greater than 1050 ft.-lbs.

(ii) A lever arm with a minimum length of 24 inches. The distance from the center of the engine torque measuring device to the point of force measurement or application shall be accurate to within 0.010 inches. The arm must be balanced or the hanging torque of the arm must be known within ±0.1 ft.-lbs.

(iii) Transfer of calibration or span from a dynamometer "case" torque value to the engine flywheel torque measuring device is permitted only under static or steady state conditions.

(3) Other techniques may be used if shown to be equivalent and if approved by the Administrator.

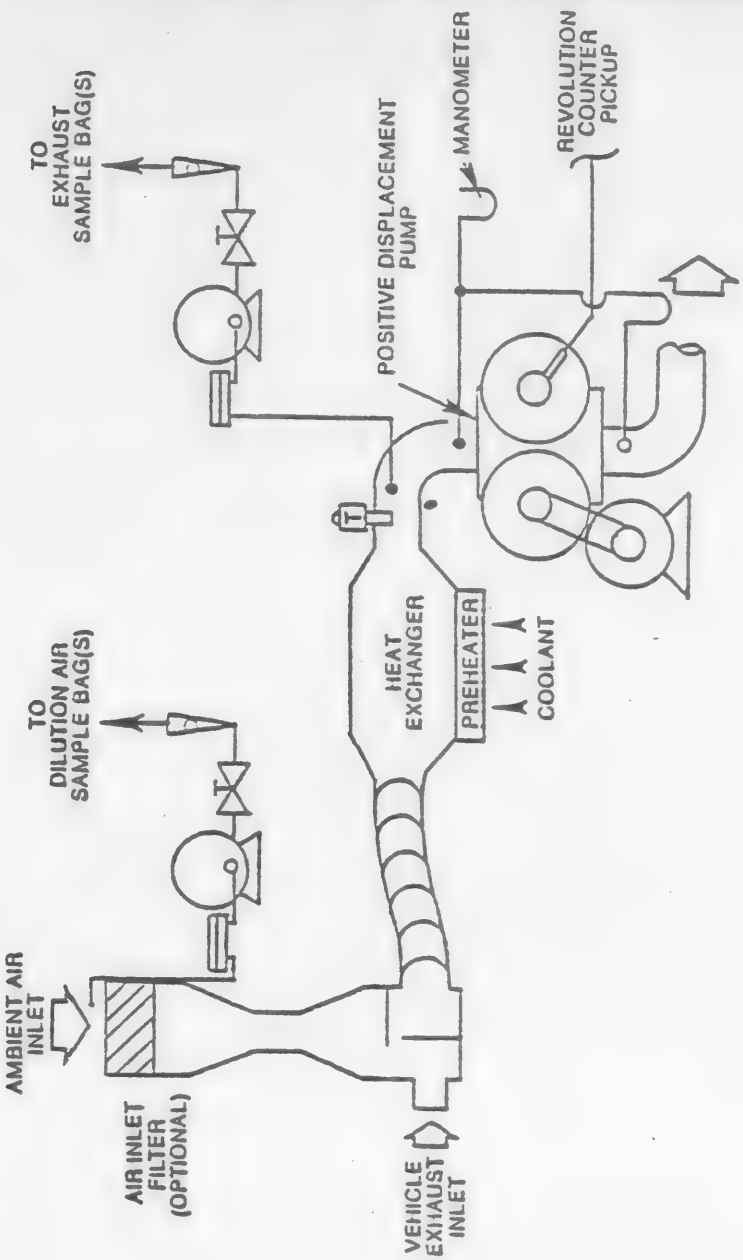
12. A new § 86.1309–86 is added and reads as follows:

§ 86.1309–86 Exhaust gas sampling system; gasoline-fueled engines.

(a)(1) *General.* The exhaust gas sampling system is designed to measure the true mass emissions of engine exhaust. In the CVS concept of measuring mass emissions, two conditions must be satisfied: the total volume of the mixture of exhaust and dilution air must be measured, and a continuously proportioned sample of volume must be collected for analysis. Mass emissions are determined from the sample concentration and total flow over the test period. The sampling and continuous analysis system specified in § 86.1310–86 for diesel engines may be used for testing gasoline-fueled engines if the systems meet all of the requirements for such systems as specified in this Subpart.

(2) *Positive displacement pump.* The positive displacement pump—constant volume sampler (PDP—CVS), Figure N86–1, satisfies the first condition by metering at a constant temperature and pressure through the pump. The total volume is measured by counting the revolutions made by the calibrated positive displacement pump. The proportional sample is achieved by sampling at a constant flow rate.

BILLING CODE 6560–26–M



(SEE FIG. N86-7 FOR SYMBOL LEGEND)

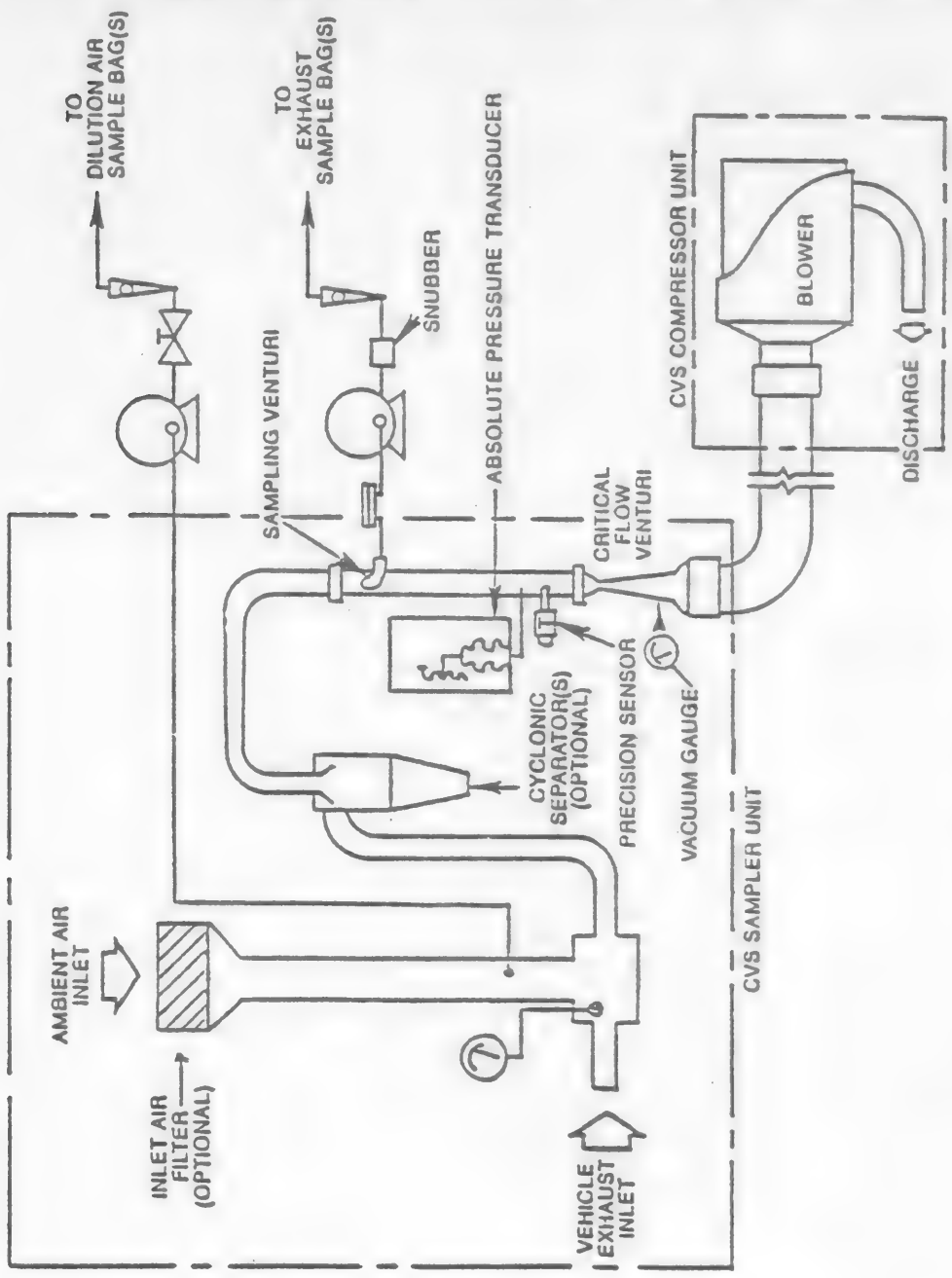
FIGURE N86-1 — EXHAUST GAS SAMPLING SYSTEM PDP-CVS

FOR GASOLINE FUELED ENGINES

BILLING CODE 6560-26-C

(3) *Critical flow venturi.* The operation of the critical flow venturi—constant volume sampler (CFV–CVS), Figure N86–2, is based upon the principles of fluid dynamics associated with critical flow. The CVF system is commonly called a constant volume system (CVS) even though the flow varies. It would be more proper to call the critical flow venturi (CFV) system a constant proportion sampling system since proportional sampling throughout temperature excursions is maintained by use of a small CFV in the sample line. The variable mixture flow rate is maintained at sonic velocity, which is inversely proportional to the square root of the gas temperature, and is computed continuously. Since the pressure and temperature are the same at both venturi inlets, the sample volume is proportional to the total volume.

BILLING CODE 6560-26-M



(SEE FIG. N86-7 FOR SYMBOL LEGEND)

FIGURE N86-2 — EXHAUST GAS SAMPLING SYSTEM (CFV-CVS)
FOR GASOLINE FUELED ENGINES

BILLING CODE 6560-26-C

(4) *Other systems.* Other sampling and/or analytical systems including the systems described in § 86.1310–86 for diesel engines may be used if shown to yield equivalent results, and if approved in advance by the Administrator.

(b) *Component description, PDP–CVS.* The PDP–CVS, Figure N86–1, consists of a dilution air filter and mixing assembly, heat exchanger, positive displacement pump, sampling system, and associated valves, pressure and temperature sensors. The PDP–CVS shall conform to the following requirements:

(1) Static pressure variations at the tailpipe(s) of the engine shall remain within ±5 inches of water (1.2 kPa) of the static pressure variations measured during a dynamometer engine cycle with no connection to the tailpipe(s). (Sampling systems capable of maintaining the static pressure to within ±1 inch of water (0.25 kPa) will be used by the Administrator if a written request substantiates the need for this closer tolerance.)

(2) The gas mixture temperature, measured at a point immediately ahead of the positive displacement pump, shall be within ±10°F (5.6° C) of the designed operating temperature at the start of the test. The designed operating temperature may be estimated from the average operating temperature from similar tests. The gas mixture temperature variation (after the heat exchanger) during the entire test shall be limited to ±10°F (5.6° C) from its value at the start of the test. The temperature measuring system shall have an accuracy and precision of ±2° F (1.1°C).

(3) The pressure gauges shall have an accuracy and precision of ±3mm Hg (0.4 kPa).

(4) The flow capacity of the CVS shall be large enough to eliminate water condensation in the system.

(5) Sample collection bags for dilution air and exhaust samples shall be sufficient size so as not to impede sample flow.

(c) *Component description, CFV–CVS.* The CFV–CVS, Figure N86–2 consists of a dilution air filter (optional) and mixing assembly, optional cyclonic particulate separator(s), sampling venturi, critical flow venturi, sampling system, and assorted valves, pressure and temperature sensors.

The CFV–CVS shall conform to the following requirements:

(1) Static pressure variations at the tailpipe(s) of the vehicle shall remain within ±5 inches of water (1.2 kPa) of the static pressure variations measured during a dynamometer engine cycle with no connection to the tailpipe(s). (Sampling systems capable of maintaining the static pressure to within ±1 inch of water (0.25 kPa) will be used by the Administrator if a written request substantiates the need for this closer tolerance.)

(2) The temperature measuring system shall have an accuracy and precision of ±2° F (1.1° C) and a response time of 0.100 seconds to 62.5 percent of a temperature change (as measured in hot silicone oil).

(3) The pressure measuring system shall have an accuracy and precision of ±3mm Hg (0.4 kPa).

(4) The flow capacity of the CVS shall be large enough to prevent water condensation in the system.

(5) Sample collection bags for dilution air and exhaust samples shall be of sufficient size so as not to impede sample flow.

13. A new § 86.1310–86 is added and reads as follows:

§ 86.1310–86 Exhaust gas sampling and analytical system; diesel engines.

(a) *General.* The exhaust gas sampling system described in this paragraph is designed to measure the true mass of both gaseous and particulate emissions in the exhaust of heavy-duty diesel engines. This system utilizes the CVS concept (described in § 86.1309–86) of measuring mass emissions of NO_x, CO, CO_2, and particulate. A continuously integrated system is required for HC measurement, and is allowed for NO_x, CO, and CO_2. The mass of gaseous emissions is determined from the sample concentration and total flow over the test period. The mass of particulate emissions is determined from a proportional mass sample collected on a filter and from the total flow over the test period. General requirements are as follows:

(1) This sampling system requires the use of a PDP–CVS, or a CFV–CVS with heat exchanger or with electronic flow compensation. Figure N86–3 is a schematic drawing of the PDP system. Figure N86–4 is a schematic drawing of the CFV system.

BILLING CODE 6560-26-M

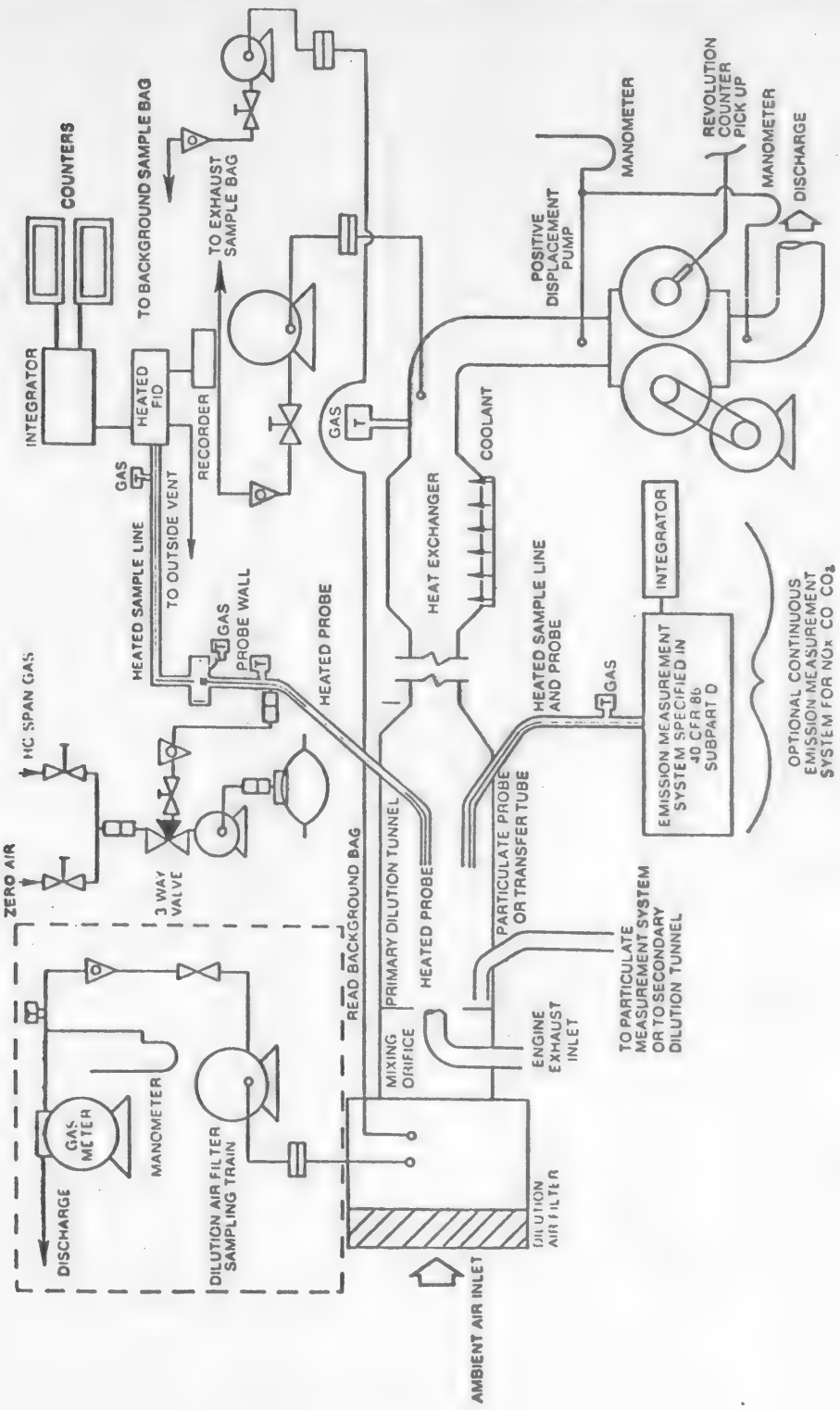


FIGURE N86-3
GASEOUS AND PARTICULATE EMISSIONS SAMPLING SYSTEM (PDP-CVS)
(FOR DIESEL ENGINES ONLY)
(SEE FIGURE N86-7 FOR SYMBOL LEGEND)

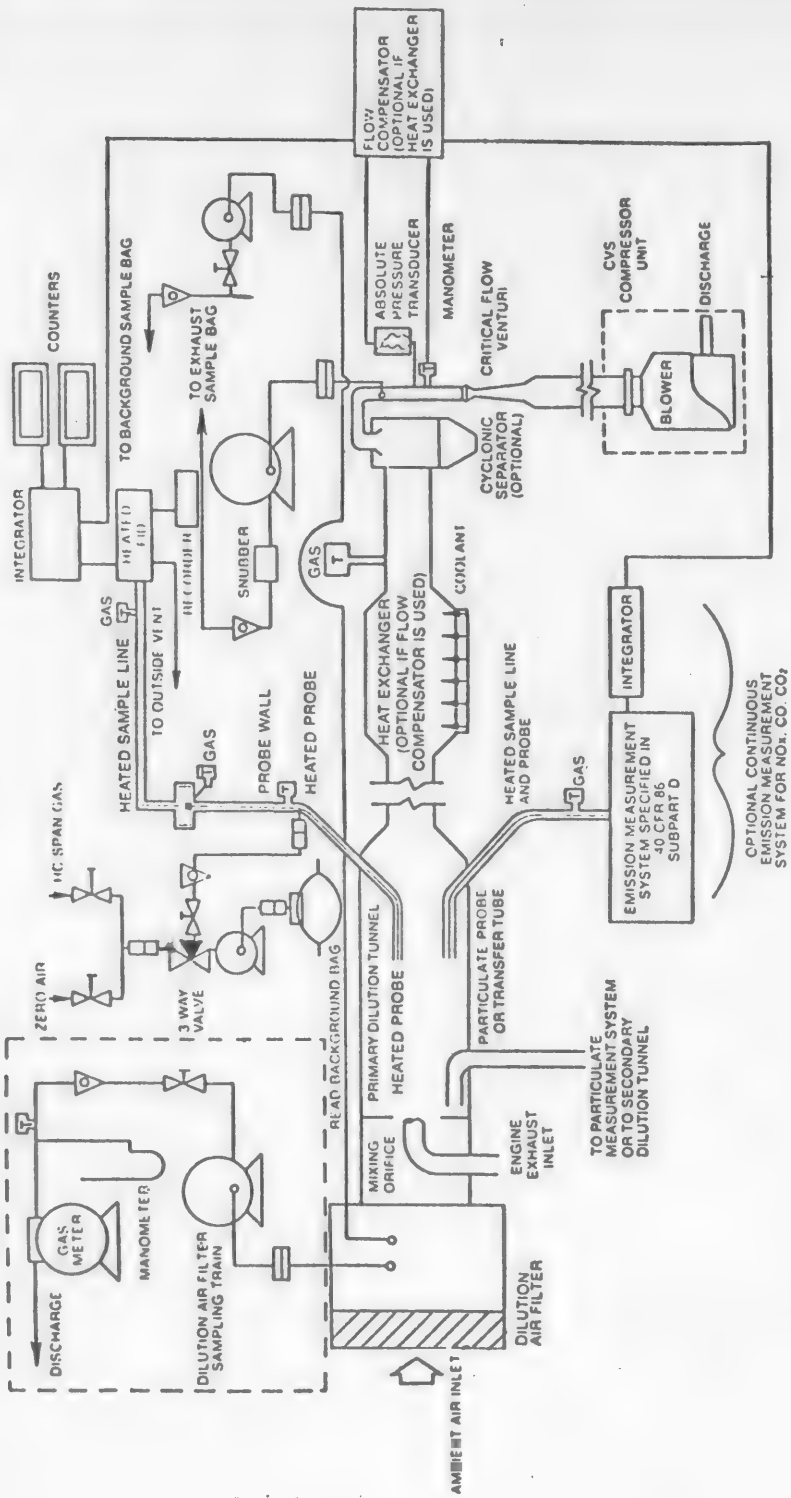


FIGURE N86-4
GASEOUS AND PARTICULATE EMISSIONS SAMPLING SYSTEM (CFV-CVS)
(FOR DIESEL ENGINES ONLY)
(SEE FIGURE N86-7 FOR SYMBOL LEGEND)

BILLING CODE 6560-26-C

(2) The HC analytical system for diesel engines requires a heated flame ionization detector (HFID) and heated sample system.

(i) The HFID sample must be taken directly from the diluted exhaust stream through a heated probe and integrated continuously over the test cycle. Unless compensation for varying flow is made, the HFID must be used with a constant flow system to insure a representative sample.

(ii) The heated probe shall be located downstream of a mixing chamber that provides a uniform sample distribution across the CVS duct.

(iii) The dillution tunnel similar to those used for diesel particulate sampling may be used as a mixing chamber for gaseous emissions also.

(3) *Option:* Continously integrated measurement of diluted NO_x, CO, and CO_2 is permitted; however, prior approval of the Administrator is required. Test results will be required as well as engineering data and detailed system specifications to gain this approval. Minimum requirements and technical specifications are given in (b)(5) of this section.

(4) Bag sampling (§ 86.1309–86) and analytical (§ 86.1311–86) capabilities as shown in N86–3 (or Figure N86–4) are required, to provide both gaseous and particulate emissions sampling capabilities from a single system if NO_x, CO or CO_2 are not measured continuously.

(5) Since various configurations can produce equivalent results, exact conformance with these drawings is not required. Additional components such as instruments, valves, solenoids, pumps, and switches may be used to provide additional information and coordinate the functions of the component systems.

(6) Other sampling and/or analytical systems may be used if shown to yield equivalent results and if approved in advance by the Administrator.

(b) *Component description.* The components necessary for diesel exhaust sampling shall meet the following requirements:

(1) The PDP–CVS, shall conform to all of the requirements listed for the exhaust gas PDP–CVS (§ 86.1309–86(b)). The CFV–CVS shall conform to all of he requirements listed for the exhaust gas CFV-CVS (§ 86.1309–86(c)). In addition, the CVS must conform to the following requirements:

(i) The flow capacity of the CVS must be sufficient to maintain the diluted exhaust stream at a temperature that will satisfactorily measure particulate and/or hydrocarbon measurements. This may be achieved by either of the following methods:

(A) *Single-dilution method.* A CVS of sufficient flow capacity to maintain a temperature of 125° F (51.7° C) or less at the sampling zone may be used with the primary-dilution tunnel. Direct sampling of the particulate material may then take place (Figure N86–5).

BILLING CODE 6560-26-M

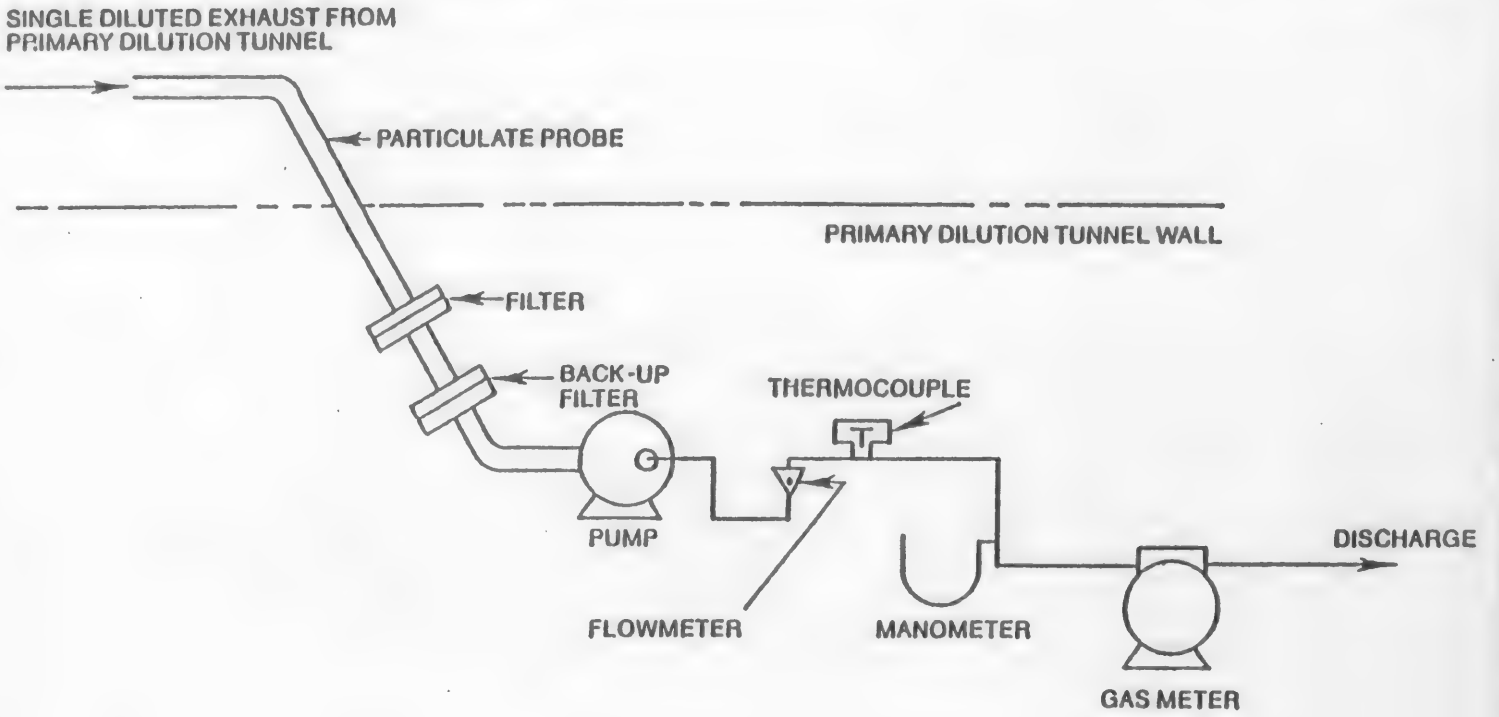


FIGURE N86-5
SINGLE DILUTION PARTICULATE MEASUREMENT SYSTEM
(FOR DIESEL ENGINES ONLY)
(SEE FIGURE N86-7 FOR SYMBOL LEGEND)

BILLING CODE 6560-26-C

(B) *Double-dilution method.* A smaller size CVS may be used with a smaller primary-dilution tunnel (i.e., smaller than the dilution tunnel or CVS described in § 86.1310–86(b)(1)(A)), and a secondary-dilution tunnel system (Figure N86–6). The flow capacity of the CVS must be sufficient to maintain the diluted exhaust stream in the primary-dilution tunnel at a temperature of 375° F (191° C) or less at the sampling zone. The secondary dilution tunnel system must be designed to provide sufficient secondary dilution air to maintain the double diluted exhaust stream at a temperature of 125° F (51.7° C) or less immediately before the particulate filter.

BILLING CODE 6560-26-M

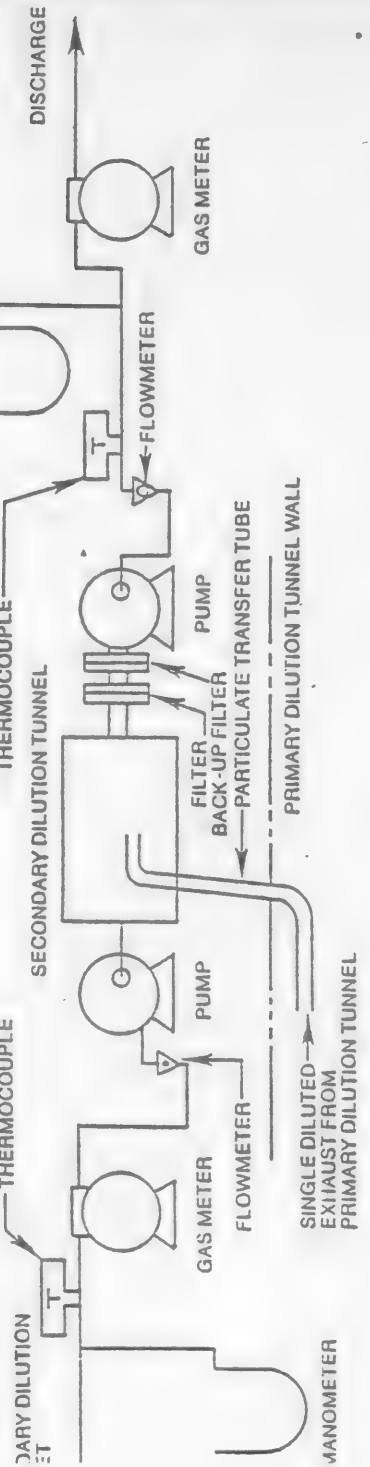


FIGURE N86-6
DOUBLE DILUTION PARTICULATE MEASUREMENT SYSTEM
(FOR DIESEL ENGINES ONLY)
(SEE FIGURE N86-7 FOR SYMBOL LEGEND)

BILLING CODE 6560-26-C

(ii) for the CFV–CVS, a heat exchanger or electronic flow compensation (which includes the particulate sample flows) is required (see Figure 86–4).

(iii) For the CFV-CVS, the gas mixture temperature, measured at a point immediately ahead of the critical flow venturi, shall be within ±20° F (11° C) of the designed operating temperature at the start of the test. The gas mixture temperature variation from its value at the start of the test shall be limited to ±20° F (11° C) during the entire test. The temperature measuring system shall have an accuracy and precision of ±2° F (1° C).

(2) The transfer of heat from the engine exhaust gas shall be minimized between the point where it leaves the chassis exhaust system and the point where it enters the primary-dilution tunnel airstream. To accomplish this, a short length (not more than 12 feet (3.66 m) if uninsulated, or not more than 20 feet (6.1 m), if insulated) of smooth stainless steel tubing rom the muffler to the primary-dilution tunnel is required. This tubing shall have a maximum inside diameter of 6.0 inches (15.2 cm). Short sections (altogether not to exceed 20 percent of the entire tube length) of flexible tubing at connection points are allowed. If insulated, the radial thickness of the insulation must be at least R inches, where,

R=16(k)−2(r), where
k=Thermal conductivity of the insulating material (Btu/hr-ft-° F), and
r=Outer radius of uninsulated tubing (inches).

(3) The engine exhaust shall be directed downstream at the point where it is introduced into the primary-dilution tunnel.

(4) the primary-dilution air shall be: (i) a temperature of 77±9° F (25±5° C).

(ii) Filtered at the dilution air inlet.

(5) The primary-dilution tunnel shall be:

(i) Sized to permit development of turbulent flow (Reynolds No. >4000) and complete mixing of the exhaust and dilution air between the mixing orifice; and

(ii) At least 18 inches (43 cm) in diameter with a single-dilution system or at least 8 inches (36 cm) in diameter with a double dilution system;

(iii) Constructed of electrically conductive material which does not react with the exhaust components.

(6) The temperature of the diluted exhaust stream inside of the primary-dilution tunnel shall be sufficient to prevent water condensation.

(7) The particulate collection system must be configured in either of two basic ways, and depends upon the dilution method used. The *single-dilution* method utilizes a system that removes a single-diluted proportional sample from the primary tunnel, and then passes this sample through the collection filter (Figure N86–5).

The *double-dilution* method utilizes a collection system that transfers a single-diluted proportional sample from the primary tunnel to a secondary-dilution tunnel where the sample is further diluted, and then passes the complete double-diluted sample through the collection filter (Figure N86–6). In this system proportional sampling is achieved by; (1) introducing the secondary dilution air at a constant mass flow rate, and (2) removing the double-diluted sample at a constant mass flow rate. The requirements for these two systems follow:

(i) *Single-dilution method.* (A) The particulate sample probe shall be:

(*1*) Installed facing upstream at a point where the dilution air and exhaust air are will mixed (i.e., on the primary tunnel centerline, approximately 10 tunnel diameters downstream of the point where the exhaust enters the primary dilution tunnel).

(*2*) Sufficiently distant (radially) from other sampling probes so as to be free from the influence of any wakes or eddies produced by the other probes.

(*3*) 1.27 cm (0.5 in.) minimum inside diameter.

(*4*) The distance from the sampling tip to the filter holder shall be at least 5 probe diameters (for filters located inside of the primary dilution tunnel), but not more than 40 inches (102 cm) for filters located outside of the primary-dilution tunnel.

(*5*) Designed to minimize the deposition of particulate in the probe (e.g., bends should be as gradual as possible, protrusions (due to sensors, etc.) should be smooth and not sudden, etc.).

(B) The particulate sample pump(s) shall be located sufficiently distant from the dilution tunnel so that the inlet gas temperature is maintained at a constant temperature (±5.4° F (3° C)).

(C) The gas meters or flow instrumentation shall be located sufficiently distant from the tunnel so that the inlet gas temperature remains constant(±5° F (2.8° C)).

(ii) *Double-dilution method.* (A) The particulate sample transfer tube shall be configured and installed so that:

(*1*) The inlet faces upstream in the primary-dilution tunnel at a point where the primary-dilution air and exhaust are well mixed (i.e., on the primary tunnel centerline, approximately 10 tunnel diameters downstream of the point where the exhaust enters the primary-dilution tunnel).

(*2*) The exit faces downstream in the secondary-dilution tunnel.

(*3*) The single-diluted sample exists on the centerline of the secondary tunnel.

(B) The particulate sample transfer tube shall be:

(*1*) Sufficiently distant (radially) from other sampling probes (in the primary-dilution tunnel) so as to be free from the influence of any wakes or eddies produced by the other probes.

(*2*) 0.5 inches (1.27 cm) minimum inside diameter.

(*3*) No longer than 35 inches (91.4 cm) from inlet plane to exit plane.

(*4*) Designed to minimize the deposition of particulate during transfer (e.g., bends should be as gradual as possible protrusions (due to sensors, etc.) should be smooth and not sudden, etc.).

(*5*) Constructed of electrically conductive material which does not react with the exhaust components.

(C) The secondary dilution air shall be at a temperature of 77 ±9° F (25 ±5° C).

(D) The secondary-dilution tunnel shall be:

(*1*) 3.0 inches (7.62 cm) minimum inside diameter.

(*2*) Of sufficient length so as to provide a residence time of at least 0.25 seconds for the double-diluted sample.

(*3*) Constructed of electrically conductive material which does not react with the exhaust components.

(E) Additional dilution air must be provided so as to maintain temperature of 125° F (51.7° C) immediately before the sample filter. This dilution air must be introduced at a constant mass flow rate in order to maintain proportional sampling. Determination of the mass of air entering the secondary dilution tunnel is required. Introduction and measurement can be achieved by either of the following methods:

(*1*) A PDP-type pump flowing filtered dilution air at a constant temperature (77 ±9° F (25 ±5° C)) and pressure (atmospheric is acceptable) along with a gas meter or flow instrumentation for mass determination. (See § 86.1320–86 for calibration specifics.) The gas meter or flow instrumentation shall be located so that the inlet gas temperature remains constant (77 ±9° F (25 ±5° C)).

(*2*) A choked critical flow orifice flowing filtered dilution air. For mass determination a gas meter or other surface flow instrumentation is acceptable. (See § 86.1320–86 for calibration specifics.) The gas meter or flow instrumentation shall be located so that the inlet gas temperature remains constant (77 ±9° F (25 ±5° C)).

(F) The primary filter holder shall be located within 12.0 inches (7.5 cm) of the exit of the secondary-dilution tunnel.

(G) The particulate sample pump shall be located sufficiently distant from the dilution tunnel so that the inlet gas temperature is maintained constant (±5° F (2.8° C)).

(H) The gas meter or flow instrumentation (if double-dilution this means the downstream device) shall be located sufficiently distant from the tunnel (either primary or secondary) so that the inlet gas temperature remains constant (±5° F (±2.8° C)).

(8) *Continuous HC measurement system. (i) The continuous HC sample system (as shown in Figure N86–3 or N86–4) shall be an "overflow calibration (or span) gas" type system. In this type of system, excess span or calibration gas spills out of the probe during calibration of the analyzer.*

(ii) No other analyzers may draw a sample from the continuous HC sample probe, line or system.

(iii) The span, calibration, or background sample flow rates into the sample line shall be between 190 and 210 percent of the HFID analyzer flow rate.

(iv) The span, calibration or background gases shall enter the heated sample line no farther than 4 inches from the CVS duct or dilution tunnel outside surface.

(v) The continuous hydrocarbon probe shall be:

(A) Installed in the primary dilution tunnel facing upstream at a point where the dilution air and exhaust are well mixed (i.e., approximately 10 tunnel diameters downstream of the point where the exhaust enters the dilution tunnel).

(B) Sufficiently distant (radially) from other probes so as to be free from the influence of any wakes or eddies produced by the other probes.

(C) Heated and insulated over the entire length to maintain a 375° ±20° F (191° ±11° C) wall temperature. The radial thickness of the insulation must be at least R inches, where

R=16(k)−2(r), where
k=Thermal conductivity of insulating material (Btu/hr-ft-° F), and
r=Outer radius of uninsulated probe (inches).

(D) 0.5 in. (1.27 cm) minimum inside diameter.

(vi) It is intended that the total hydrocarbon probe be free from cold spots (i.e., free from spots where the probe *wall* temperature is less than 355° F (180° C)).

(vii) The dilute exhaust *gas* flowing in the total hydroicarbon sample system shall be:

(A) At 375° ±10° F (191° ±6° C) immediately before the heated filter. This *gas* temperature will be determined by a temperature sensor located at the exit of the heated sample line. The sensor shall have an accuracy and precision of ± 2° F(1.1° C).

(B) at 375° ±10° F (191° ±6° C) immediately before HFID. This *gas* temperature will be determined by a temperature sensor located at the exit of the heated sample line. The sensor shall have an accuracy and precions of ±2° F (1.1° C).

(viii) It is intended that the dilute exhaust gas flowing in the total hydrocarbon sample system be between 365° F and 385° F (185° C and 197° C) *gas* temperature.

(ix) The response time of the continuous measurement system shall be:

(A) 1.5 seconds from an instantaneous step change at the probe entrance to the analyzer to within 95 percent of the step change.

(B) 5.5 seconds from an instantaneous step change at the entrance to the sample probe or overflow span gas port to within 95 percent of the step change.

(C) For the purpose of verification of response times, the step change shall be at least 60 percent of fullscale chart deflection.

(9) Optional continuously integrated NO_x, CO, and CO_2 measurement system.

(i) The sample probe shall:

(A) Be in the same plane as the continuous HC probe, but shall be sufficiently distant (radially) from other probes so as to be free from the influences of any wakes or eddies produced by other probes.

(B) Shall face upstream.

(C) Heated and insulated over the entire length to prevent water condensation, minimum temperature is 55°C (131°F). Sample *gas* temperature immediately before the first filter in the system shall be at least 55°C (131°F).

(ii) The continuous NO_x, CO, or CO_2 sampling and analysis system shall conform to the specifications of 40 CFR 86, Subpart D with the following exceptions and revisions:

(A) The system components required to be heated by Subpart D need only be heated to prevent water condensation, the minimum temperature allowed is 55°C (131°F).

(B) The system response defined in § 86.329–79 shall be no greater than 5.5 seconds. Longer response time may be allowed if analysis system response time is coordinated with CVS flow fluctuations, is shown to be equivalent to the 5.5 second system, and if prior approval is granted by the Administrator.

(C) Alternative NO_x measurement techniques outlined in § 86.346–79 are not permitted for NO_x measurement in this Subpart.

(D) All analytical gases shall conform to the specifications of § 86.1314–86.

(E) Any range on a linear analyzer below 155 ppm shall have and use a calibration curve conforming to § 86.330–79.

(F) The measurement accuracy requirements specified in § 86.338–79 are superseded by those specified in § 86.1338–86.

(iii) The chart deflections of analyzers with non-linear calibration curves shall be converted to concentration values by the calibration curve(s) specified in Subpart D (86.330–79) before flow correction (if used) and subsequent integration takes place.

(c) *Filters, particulate sampling.*—(1) *Filter acceptance criteria.* Valid diesel particulate net filter weights shall be accepted according to the following criteria:

(i) During the cold start phase of the heavy-duty transient cycle and again during the hot start phase of the heavy-duty transient cycle dilute exhaust will be simultaneously sampled by paired primary test and back-up test filters.

(ii) The back-up filter holder shall be located 3 to 4 inches downstream of the primary filter holder.

(iii) The net weight of particulate material collected on each primary test filter and each back-up test filter shall be determined by the procedure outlined in § 86.1339–85.

(iv) A ratio of net weights will be determined by the following formula:

$$\text{Ratio of net weights} = \frac{(\text{Mass Particulate})_{\text{Test filter}}}{(\text{Mass Particulate})_{\text{Test filter}} + (\text{Mass Particulate})_{\text{Back-up filter}}}$$

(v) If the ratio is greater than 0.95, then particulate emissions calculations are based on the net weight of the primary filter only.

(vi) If the ratio is less than 0.95, then particulate emissions calculations are based on the combined net weights of the back-up filter and the primary test filter.

(2) The particulate filter must have a minimum 70 mm diameter (60 mm stain area). Larger diameter filters are also acceptable. (Larger diameter filters may be desirable in order to reduce the pressure drop across the filter when testing vehicles which produce large amounts of particulate.)

(3) The recommended minimum loading on the 70 mm filter is 5.3 milligrams. Equivalent loadings (ie., mass/stain area) are recommended for larger filters. For equivalency calculations assume the 70 mm loading has a 60 mm stain diameter.

(4) Fluorocarbon coated glass fiber filters or fluorocarbon based (membrane) filters are required for particulate collection.

14. A new § 86.1311–86 is added and reads:

§ 86.1311–86 Exhaust gas analytical system. CVS bag sample.

(a) *Schematic drawings.* Figure N86–7 is a schematic drawing of the exhaust gas analytical system used for analyzing CVS bag samples from either gasoline-fueled or diesel engines. The schematic of the hydrocarbon analysis train for diesel engines is shown as part of Figure N86–3 or N86–4. Since various configurations can produce accurate results, exact conformance with the drawing is not required. Additional components such as instruments, valves, solenoids, pumps and switches may be used to provide additional information and coordinate the functions of the component systems.

BILLING CODE 6560-26-M

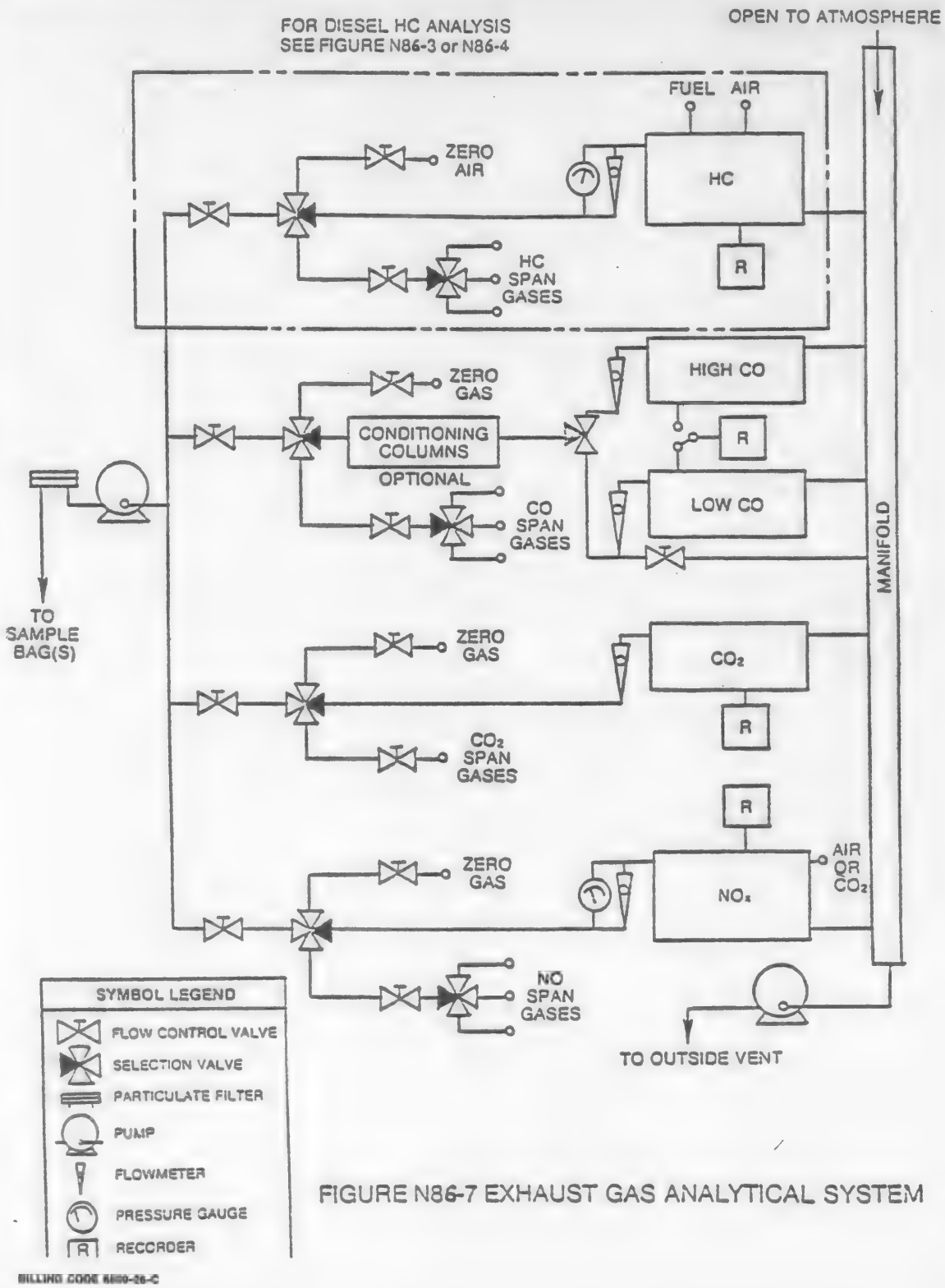


FIGURE N86-7 EXHAUST GAS ANALYTICAL SYSTEM

BILLING CODE 6560-26-C

(b) *Major component description.* The analytical system. Figure N86–7, consists of a flame ionization detector (FID) for the determination of hydrocarbons, nondispersive infrared analyzers (NDIR) for the determination of carbon monoxide and carbon dioxide and a chemiluminescence analyzer (CL) for the determination of oxides of nitrogen. A heated flame ionization detector (HFID) is used for the continuous determination of hydrocarbons from diesel engines, Figure N86–3 or N86–4.

The exhaust gas analytical system shall conform to the following requirements:

(1) The CL requires that the nitrogen dioxide present in the sample be converted to nitric oxide before analysis. Other types of analyzers may be used if shown to yield equivalent results and if approved in advance by the Administrator.

(2) The carbon monoxide (NDIR) analyzer may require a sample conditioning column containing $CASO_4$, or indicating silica gel to remove water vapor and containing ascarite to remove carbon dioxide from the CO analysis stream.

(i) If CO instruments are used which are essentially free of CO_2 and water vapor interference, the use of the conditioning column may be deleted. (See § 86.1322–86 and § 86.1342–86.)

(ii) A CO instrument will be considered to be essentially free of CO_2 and water vapor interference if its response to a mixture of 3 percent CO_2 in N_2 which has been bubbled through water at room temperature produces an equivalent CO response, as measured on the most sensitive CO range, which is less than 1 percent of full scale CO concentration on ranges above 300 ppm full scale or less than 3 ppm on ranges below 300 ppm full scale. (See § 86.1322–86.)

(c) *Alternate analytical systems.* Analysis systems meeting the specifications of 40 CFR 86, Subpart D may be used for testing this Subpart (N) with the exception of §§ 86.346–86 and 86.347–86, provided that the Subpart D systems meet the specifications of this Subpart. Heated analyzers may be used in their heated configuration.

(d) *Other analyzers and equipment.* Other types of analyzers and equipment may be used if shown to yield equivalent results and if approved in advance by the Administrator.

15. A new § 86.1312–86 is added and reads as follows:

§ 86.1312–86 Weighing chamber (or room) and microgram balance specifications.

(a) *Ambient conditions.*— (1) *Temperature.* The temperature of the chamber in which the particulate filters are conditioned and weighed shall be maintained to within ±10° F (6° C) of a set point between 68° F (20° C) and 86° F (30° C) during all filter conditioning and filter weighing.

(2) *Humidity.* The relative humidity of the chamber in which the particulate filters are conditioned and weighed shall be maintained to within ±10 percent of a set point between 30 and 70 percent during all filter conditioning and filter weighing.

(3) The environment shall be free from any ambient contaminates (such as dust) that would settle on the particulate filters during their stabilization. It is required that two reference filters remain in the weighing room at all times, and that these filters be weighed at the beginning and end of each conditioning period. If the weight of either or both of these two reference filters changes by more than ±1.0 percent of the nominal filter loading (a minimum of 5.3 milligrams, if possible) during the conditioning period, then all filters in the process of being stabilized should be discarded, and any tests repeated. The reference filters shall be changed at least once per month.

(b) *Microgram balance specifications.* The microgram balance used to determine the weights of all filters shall have an accuracy and a readability of one microgram.

16. A new § 86.1313–86 is added and reads as follows:

§ 86.1313–86 Fuel specifications.

(a) *Gasoline.* (1) Gasoline having the following specifications will be used by the Administrator in exhaust emission testing. Gasoline having the following specifications or substantially equivalent specifications approved by the Administrator, shall be used by the manufacturer in exhaust testing, except that the lead and octane specifications do not apply.

Item	ASTM	Leaded	Unleaded
Octane, research, minimum.	D2699	[illegible]	93
Pb. (organic), gm/U.S. gallon.		[1] 1.4	0.00–0.05
Distillation range:			
IBP, °F	D86	75–95	75–95
10 percent point, °F.	D86	120–135	120–135
50 percent point, °F.	D86	200–230	200–230
90 percent point, °F.	D86	300–325	300–325
EP, °F (maximum).	D86	415	415
Sulphur, weight percent, (max).	D1266	0.10	0.10
Phosphorus, gm/U.S. gallon (max).		0.01	0.005
RVP, psi	D323	8.7–9.2	8.7–9.2
Hydrocarbon composition:			
Olefins, percent, (max).	D1319	10	10
Aeromatics, percent (max).	D1319	35	35
Saturates	D1319	[2]	[2]

[1] Minimum.
[2] Remainder.

(2) Gasoline representative of commercial gasoline which will be generally available through retail outlets shall be used in service accumulation. For leaded gasoline the minimum lead content shall be 1.4 grams per U.S. gallon, except that where the Administrator determines that vehicles represented by a test vehicle will be operated using gasoline of different lead content than that prescribed in this paragraph, he may consent in writing to use of a gasoline with a different lead content. The octane rating of the gasoline used shall be not higher than 1.0 Research octane number above the minimum recommended by the manufacturer and have a minimum sensitivity of 7.5 octane numbers, where sensitivity is defined as the Research octane number minus the Motor octane number. The Reid Vapor Pressure of the gasoline used shall be characteristic of the motor fuel used during the season in which the service accumulation takes place.

(3) The specification range of the gasoline to be used under paragraph (a)(2) of this section shall be reported in accordance wih § 86.084–21(b)(3).

(b) *Diesel fuel.* (1) The diesel fuels employed for testing shall be clean and bright, with pour and cloud points adequate for operability. The diesel fuel may contain nonmetallic additives as follows: Cetane improver, metal deactivator, antioxidant, dehazer, antirust, pour depressant, dye, and dispersant.

(2) Diesel fuel meeting the following specifications, or substantially equivalent specifications approved by the Administrator, shall be used in exhaust emissions testing. The grade of diesel fuel recommended by the engine manufacturer commercially designated as "Type 1–D" or "Type 2–D" grade diesel fuel shall be used.

Item	ASTM	Type 1–D	Type 2–D
Cetane	D613	48–54	42–50
Distillation range:			
IBP °F	D86	330–390	340–400
10 percent point, °F.	D86	370–430	400–460
50 percent point, °F.	D86	410–480	470–540

Item	ASTM	Type 1–D	Type 2–D
90 percent point, °F.	D86	460–520	550–610
EP, °F	D86	500–560	600–660
Gravity, °API	D287	40–44	33–37
Total Sulfur, percent.	D129 or D2622.	0.05–0.20	0.2–0.5
Hydrocarbon composition:			
Aromatics, percent.	D1319	[1] 8	[1] 27
Parafins, Naphthenes, Olenfins.	D1319	(2)	(2)
Flashpoint, °F (minimum).	D93	120	130
Viscosity, Centistokes.	D445	1.6–2.0	2.0–3.2

[1] Minimum.
[2] Remainder.

(3) Diesel fuel meeting the following specifications, or substantially equivalent specifications approved by the Administrator, shall be used in service accumulation. The grade of diesel fuel recommended by the engine manufacturer, commercially designated as "Type 1–D" or "Type 2–D" grade diesel fuel shall be used.

Item	ASTM	Type 1–D	Type 2–D
Cetane (minimum)	D613	42–56	30–58
Distillation range: 90 percent point, °F.	D86	440–530	540–630
Gravity °APM	D287	39–45	30–42
Total sulfur, percent (minimum).	D129 or D2622.	[1] 0.05	0.2
Flashpoint, °F (minimum).	D93	120	130
Viscosity, centistokes.	D455	1.2–2.2	1.5–4.5

[1] Minimum.

(4) Other petroleum distillate fuels may be used for testing and service accumulation provided they are:

(i) Commercially available;

(ii) Information, acceptable to the Administrator, is provided to show that only the designated fuel would be used in customer service;

(iii) Use of a fuel listed under paragraphs(b)(2) and (b)(3) of this section would have a detrimental effect on emissions or durability;

(iv) Written approval from the Administrator of the fuel specifications must be provided prior to the start of testing.

(5) The specification range of the fuels to be used under paragraphs (b)(2), (b)(3), and (b)(4) of this section shall be reported in accordance with § 86.084–21(b)(3).

17. A new § 86.1314–86 is added and reads as follows:

§ 86.1314–86 Analytical gases.

(a) Gases for the CO and CO_2 analyzers shall be singl blends of CO and CO_2 respectively using nitrogen as the diluent.

(b) Gases for the hydrocarbon analyzer shall be single blends of propane using air as the diluent.

(c) Gases for the NO_x analyzer shall be single blends of NO named as NO_x with a maximum NO_2 concentration of 5 percent of the nominal value using nitrogen as the diluent.

(d) Fuel for the FID shall be a blend of 40±2 percent hydrogen with the balance being helium. The mixture shall contain less than 1 ppm equivalent carbon response. 98 to 100 percent hydrogen fuel may be used with advance approval of the Administrator.

(e) The allowable zero gas (air or nitrogen) impurity concentrations shall not exceed 1 ppm equivalent carbon response, 1 ppm carbon monoxide, 0.04 percent (400 ppm) carbon dioxide and 0.1 ppm nitric oxide.

(f)(1) "Zero-grade air" includes artificial "air" consisting of a blend of nitrogen and oxygen with oxygen concentrations between 18 and 21 mole percent.

(2) Calibration gases shall be traceable to within 1 percent of NBS gas standards, or other gas standards which have been approved by the Administrator.

(3) Span gases shall be accurate to within 2 percent of true concentration, where true concentration refers to NBS gas standards, or other gas standards which have been approved by the Administrator.

(g) The use of proportioning and precision blending devices to obtain the required gas concentrations is allowable provided their use has been approved in advance by the Administrator.

18. A new 86.1315–86 is added and reserved as follows:

§ 86.1315–86 [Reserved]

19. A new § 86.1316–86 is added and reads as follows:

§ 86.1316–86 Calibrations; frequency and overview.

(a) Calibrations shall be performed as specified in §§ 86.1318–86 through 86.1326–86.

(b) At least monthly or after any maintenance which could alter calibration, the following calibrations and checks shall be performed:

(1) Calibrate the hydrocarbon analyzer, carbon dioxide analyzer, cargon monoxide analyzer, and oxides of nitrogen analyzer.

(2) Calibrate the engine dynamometer flywheel torque and speed measurement transducers.

(3) Calibrate the engine flywheel torque and speed feedback signals.

(c) At least weekly or after any maintenance which could alter calibration, the following calibrations and checks shall be performed:

(1) Check the oxides of nitrogen converter efficiency, and;

(2) Perform a CVS system verification.

(d) The CVS positive displacement pump or critical flow venturi shall be calibrated following initial installation, major maintenance or as necessary when indicated by the CVS system verification (described in § 86.1319–86).

(e) Sample conditioning columns, if used in the CO analyzer train, should be checked at a frequency consistent with observed column life or when the indicator of the column packing begins to show deterioration.

20. A new § 86.1317–86 is added and reserved as follows:

§ 86.1317–86 [Reserved]

21. A new § 86.1318–86 is added and reads as follows:

§ 86.1318–86 Engine dynamometer system calibration.

(a) The engine flywheel torque and engine speed measurement transducers shall be calibrated at least once each month with the calibration equipment described in § 86.1308–86.

(b) The engine flywheel torque and speed feedback signal shall be calibrated at least once each month.

(c) Other engine dynamometer system calibrations shall be performed as dictated by good engineering practice and manufacturer's recommendations.

(d) When calibrating the engine flywheel torque transducer, any lever arm used to convert a weight or a force through a distance into a torque shall be used in a horizontal position (±5 degrees).

(e) Calibrated resistors may not be used for engine flywheel torque transducer calibration, but may be used to span the transducer prior to engine testing.

22. A new § 86.1319–86 is added and reads as follows:

§ 86.1319–86 CVS calibration.

(a) The CVS is calibrated using an accurate flowmeter and restrictor valve. The calibrated accuracy of the flowmeter shall be traceable to the National Bureau of Standards to within 1 percent of the true flow value. (Note: In no case should an upstream screen or other restriction which can effect the flow be used ahead of the flowmeter unless calibrated throughout the flow range with such a device.) The CVS calibration procedures are designed for use of a "metering venturi" type flowmeter. Properly calibrated large radius or ASME flow nozzels are considered equivalent if traceable to

NBS measurements. Other measurement systems may be used if shown to be equivalent under the test conditions in this action and if approved by the Administrator. Measurements of the various flowmeter parameters are recorded and related to flow through the CVS. Procedures used by EPA for both PDP– and CFV–CVS's are outlined below. Other procedures yielding equivalent results may be'used if approved in advance by the Administrator.

(b) After the calibration curve has been obtained, verification of the entire system may be performed by injecting a known mass of gas into the system and comparing the mass indicated by the system to the true mass injected. An indicated error does not necessarily mean that the calibration is wrong, since other factors can influence the accurancy of the system, e.g. analyzer calibration or HC hangup. A verification procedure is found in paragraph (e) of this section.

(c) *PDP calibration.* (1) The following calibration procedure outlines the equipment, the test configuration, and the various parameters which must be measured to establish the flow rate of the CVS pump.

(i) All the parameters related to the pump are simultaneously measured with the parameters related to a flowmeter which is connected in series with the pump.

(ii) The calculated flow rate ft^3/min., (at pump inlet absolute pressure and temperature) can then be plotted versus a correlation function which is the value of a specific combination of pump parameters.

(iii) The linear equation which relates the pumpflow and the correlation function is then determined.

(iv) In the event that a CVS has a multiple speed drive, a calibration for each range used must be performed.

(2) This calibration procedure is based on the measurement of the absolute values of the pump and flowmeter parameters that relate the flow rate at each point. Three conditions must be maintained to assure the accuracy and integrity of the calibration curve:

(i) The pump pressures should be measured at taps on the pump rather than at the external piping on the pump inlet and outlet. (Pressure taps that are mounted at the top center and botton center of the pump drive headplate are exposed to the actual pump cavity pressure, and therefore reflect the absolute pressure differentials.)

(ii) The temperature stability must be maintained during calibration. (Flowmeters are sensitive to inlet temperature oscillations which cause the data points to be scattered. Gradual changes in temperature are acceptable as long as they occur over a period of several minutes.)

(iii) All connections between the flowmeter and the CVS pump must be absolutely void of any leakage.

(3) During an exhaust emission test the measurement of these same pump parameters enables the user to calculate the flow rate from the calibration equation.

(4) Connect a system as shown in Figure N86–8. Although particular types of equipment are shown, other configurations that yield equivalent results may be used if approved in advance by the Administrator. For the system indicated, the following data with given accuracy are required:

BILLING CODE 6560-26-M

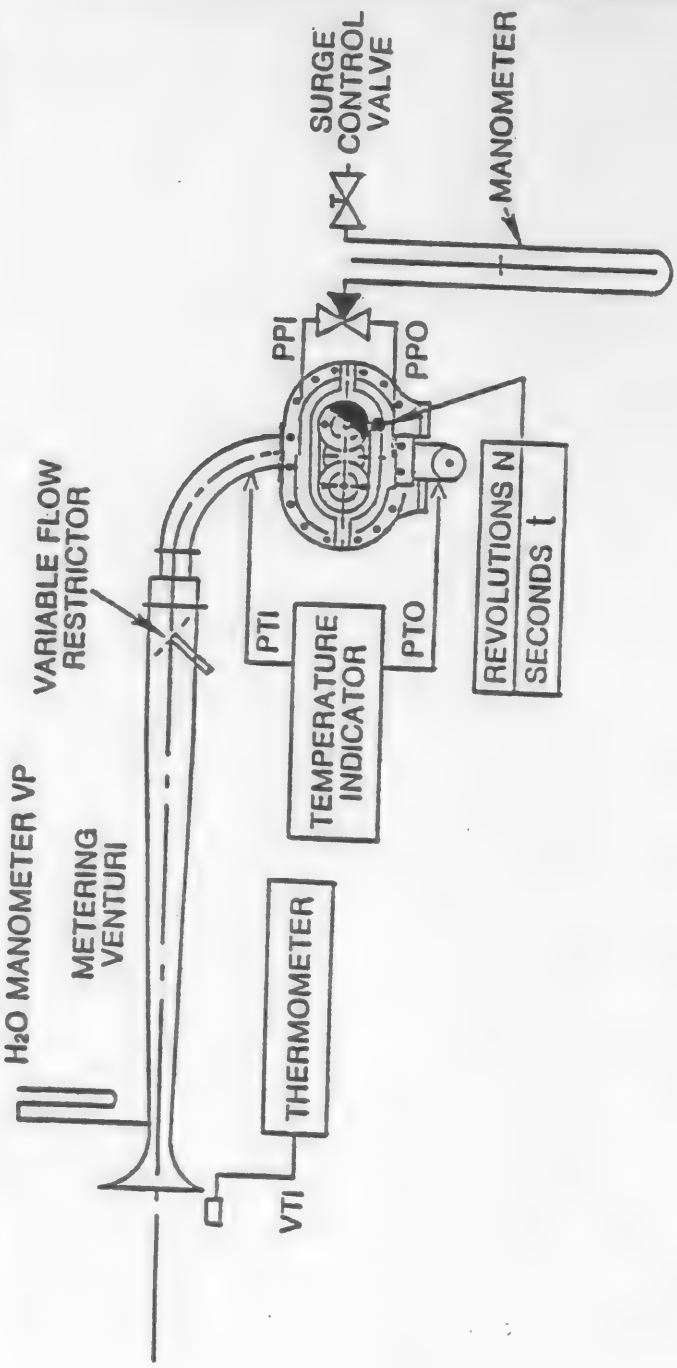


FIGURE N86-8 — PDP-CVS CALIBRATION CONFIGURATION

BILLING CODE 6560-26-C

Calibration Data Measurements

Parameter	Symbol	Units	Tolerances
Barometric pressure (corrected)	P_B	In. Hg (kPa)	±.01 in. Hg (±.034 kPa).
Ambient temperature	T_A	°F (°C)	±.5°F (±.28°C).
Air temperature into SFV	ETI	°F (°C)	±.50 °F (±.28°C).
Pressure drop between SFV inlet and throat	EDP	In. H_2O (kPa)	±.05 in. H_2O (±.012 KPa).
Air temperature at CVS pump inlet	PTI	°F (°C)	±.5°F (±.28°C).
Pressure depression at CVS pump inlet	PPI	In. fluid (kPa)	±.05 in. fluid (±.022 kPa).
Specific gravity of manometer fluid (1.75 oil)	Sp. G		
Pressure head at CVS pump outlet	PPO	In. fluid (kPa)	±.05 in. fluid (±.022 kPa).
Air Temperature at CVS pump outlet (optional)	PTO	°F (°C)	±.5°F (±.28°C).
Pump revolutions during test period	N	Revs	±1 Rev.
Elapsed time for test period	t	s	±.05 s.

(5) After the system has been connected as shown in Figure N86–8, set the variable restrictor in the wide open position and run the CVS pump for 20 minutes. Record the calibration data.

(6) Reset the restrictor valve to a more restricted condition in an increment of pump inlet depression that will yield a minimum of six data points for the total calibration. Allow the system to stabilize for 3 minutes and repeat the data acquisition.

(7) *Data analysis:* (i) The air flow rate, Qs, at each test point is calculated in standard cubic feet per minute (68° F, 29.92"HG) from the flowmeter data using the manufacturer's prescribed method.

(ii) The air flow rate is then converted to pump flow, V_o, in cubic feet per revolution at absolute pump inlet temperature and pressure.

$$V_o = \frac{Qs}{n} \times \frac{T_p}{528} \times \frac{29.92}{P_p}$$

Where:

V_o = Pump flow, ft^3/revolution (m^3/revolution) at T_p, P_p.

Qs = Meter air flow rate in standard cubic feet per minute, standard conditions are 68° F, 29.92 in. Hg (20° C, 101.3 kPa).

n = Pump speed in revolutions per minute.

T = Pump inlet temperature R(K)

P = PTI + 460 (°R), or = PTI + 273 (°K)

P = Absolute pump inlet pressure, in. Hg (kPa)

P = P − PPI (Sp. Gr/13.57) for SI units, $P_p = P_B - PPI$

Where:

P_B = barometric pressure, in. Hg (kPa).

PPI = Pump inlet depression, in. fluid (kPa).

Sp. Gr. = Specific gravity of manometer fluid relative to water.

(iii) The correlation function at each test point is then calculated from the calibration data.

$$x_o = \frac{1}{n}\sqrt{\frac{P_p}{P_e}}$$

Where:

x_o = correlation function.

ΔP_p = The pressure differential from pump inlet to pump outlet, in. Hg (kPa).
= $P_e - P_p$

P_e = Absolute pump outlet pressure, in. Hg (kPa)
= P_B + PPO (Sp. Gr./13.57) for SI units, $P_e = P_B + PPO$

(d) *CFV calibration.* (1) Calibration of the CFV is based upon the flow equation for a critical venturi. Gas flow is a function of inlet pressure and temperature:

$$Q_s = \frac{K_v P}{\sqrt{T}}$$

Where:

Q_s = flow,

K_v = calibration coefficient,

P = absolute pressure,

T = absolute temperature.

The calibration procedure described below establishes the value of the calibration coefficient at measured values of pressure, temperature and air flow.

(2) The manufacturer's recommended procedure shall be followed for calibrating electronic portions of the CFV.

(3) Measurements necessary for flow calibration are as follows:

Calibration Data Measurements

Parameter	Symbol	Units	Tolerances
Barometric Pressure (corrected)	P_B	In. Hg (kPa)	±.01 in. Hg (±.034 kPa).
Air temperature, flowmeter	ETI	°F (°C)	±.50° F (±.28° C).
Pressure drop between SFV inlet and throat	EDP	In. H_2O (kPa)	±.05 in. H_2O (±.012 kPa).
Air flow	Q_s	Ft^3/min. (m^3/min.)	±.5%.
CFV inlet depression	PPI	In. fluid (kPa)	±.05 in. fluid (±.022 kPa).
Temperature at venturi inlet	T_v	°F (°C)	±.5° F (±.28° C).
Specific gravity of manometer fluid (1.75 oil)	Sp. Gr		

(4) Set up equipment as shown in Figure N86–9 and check for leaks. Any leaks between the flow measuring devices and the critical flow venturi will seriously affect the accuracy of the calibration.

BILLING CODE 6560-26-M

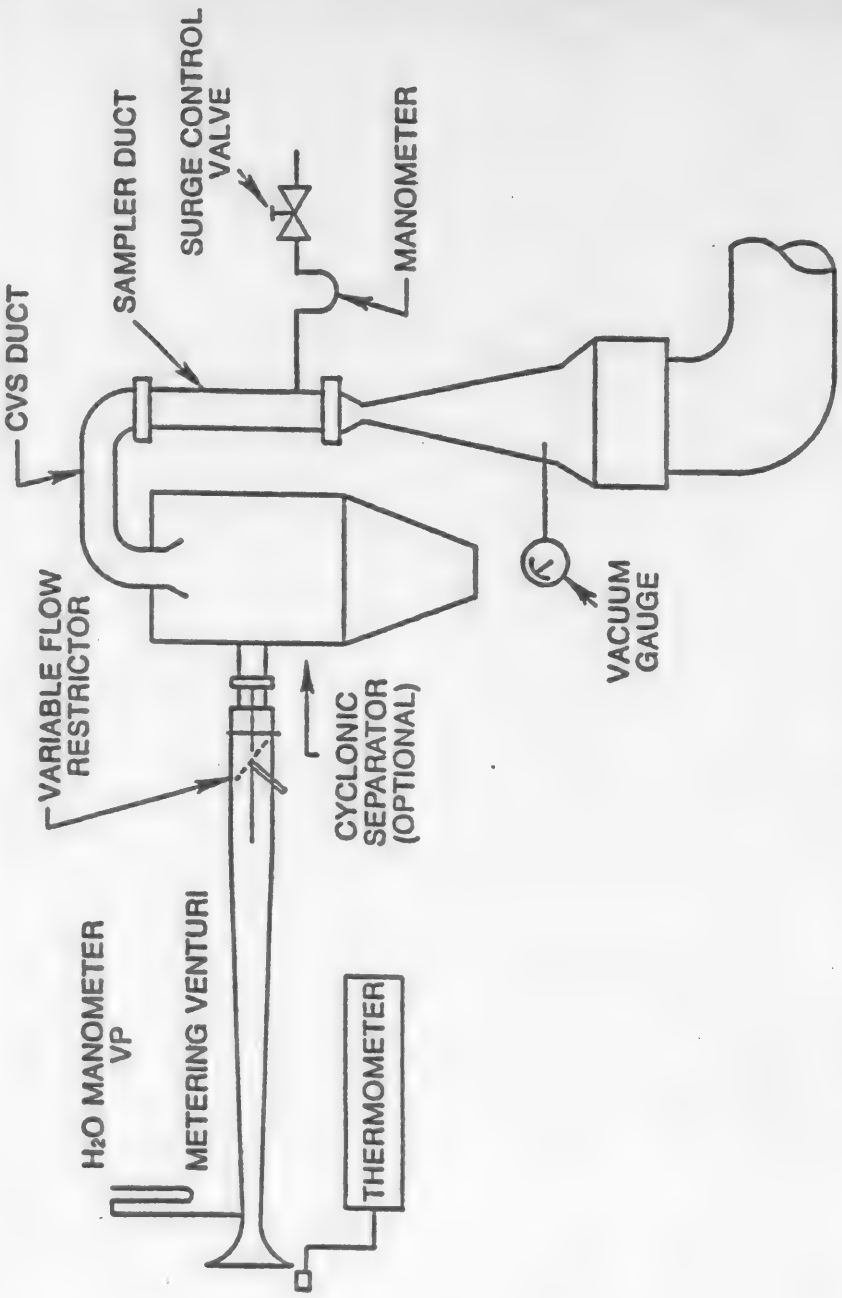


FIGURE N86-9 — CFV-CVS CALIBRATION CONFIGURATION

BILLING CODE 6560-26-C

(5) Set the variable flow restrictor to the open position, start the blower, and allow the system to stabilize. Record data from all instruments.

(6) Vary the flow restrictor and make at least 8 readings across the critical flow range of the venturi.

(7) *Data analysis.* The data recorded during the calibration are to be use in the following calculations:

(i) The air flow rate, Q_s, at each test point is calculated in standard cubic feet per minute from the flow meter data using the manufacturer's prescribed method.

(ii) Calculate values of the calibration coefficient for each test point:

$$K_v = \frac{Q_s \sqrt{T_v}}{P_v}$$

Where:

Q_s = Flow rate in standard cubic feet per minute, standard conditions are 68°F, 29.92 in. Hg (20°C, 101.3 kPa).

T_v = Temperature at venturi inlet, R(K).

P_v = Pressure at venturi inlet, mm Hg (kPa).

$= P_B$-PPI (Sp. Gr./13.57).

for SI units: $P_v = P_B - PPI$

Where:

PPI = Venturi inlet pressure depression, in. Fluid (kPa).

Sp. Gr. = Specific gravity of manometer fluid, relative to water.

(iii) Plot K_v as a function of venturi inlet pressure. For sonic flow, K_v will have a relatively constant value. As pressure decreases (vacuum increases), the venturi becomes unchoked and K_v decreases. See Figuree N86–10

BILLING CODE 6560-26-M

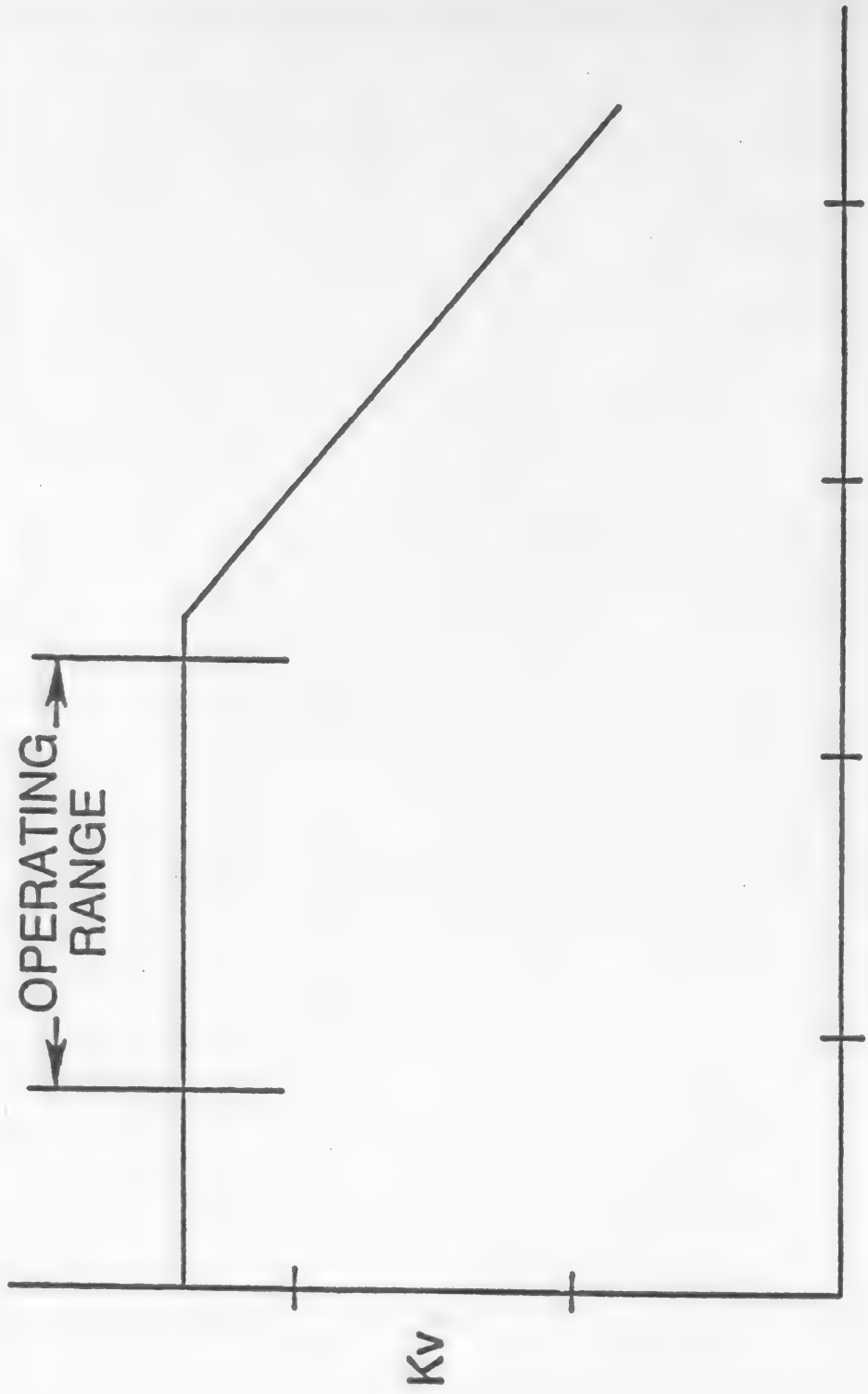


FIGURE N86-10 — SONIC FLOW CHOKING

BILLING CODE 6560-26-C

(iv) for a minimum of 8 points in the critical region calculate an average K_v and the standard deviation.

(v) If the standard deviation exceeds 0.3 percent of the average K_v take corrective action.

(e) *CVS system verification.* The following "gravimetric" technique can be used to verifty that the CVS and analytical instruments can accurately measure a mass of gas that has been injected into the system. (Verification can also be accomplished by constant flow metering using critical flow orifice devices.)

(1) Obtain a small cylinder that has been charged with pure propane or carbon monoxide gas (caution—carbon monoxide is poisonous).

(2) Determine a reference cylinder weight to the nearest 0.01 grams.

(3) Operate the CVS in the normal manner and release a quantity of pure propane or carbon monoxide into the system during the sampling period (approximately 5 minutes).

(4) The calculations of § 86.1342–86 are performed in the normal way except in the case of propane. The density of propane (17.56 g/ft³/carbon atom (0.6201 kg/m³/carbon atom)) is used in place of the density of exhaust hydrocarbons. In the case of carbon monoxide, the density of 32.97 g/ft³ (1.164 kg/m³) is used.

(5) The gravimetric mass is subtracted from the CVS measured mass and then divided by the gravimetric mass to determine the percent accuracy of the system.

(6) Good engineering practice requires that the cause for any discrepancy greater than ±2 percent must be found and corrected.

23. A new § 86.1320–86 is added and reads as follows:

§ 86.1320–86 Gas meter or flow instrumentation calibration, particulate measurement.

Sampling for particulate emissions requires the use of gas meters or flow instrumentation to determine flow through the particulate filters. This instrument shall receive initial and periodic calibrations as follows:

(a)(1) Install a standard air flow measurement device (such as laminar flow element) upstream of the instrument. This standard device shall measure air flow at standard conditions. Standard conditions are defined as 68°F (20°C) and 29.92 inches of mercury (101.3 kPa). A critical flow orifice, a bellmouth nozzle, or a laminar flow element is recommended as the standard device.

(2) Flow air through the calibration system at the sample flow rate used for particulate testing and at the backpressure which occurs during the sample test.

(3) When the temperature and pressure in the system have stabilized, measure the gas meter indicated volume of the instrument over a time period of at least 5 minutes and until a flow volume of at least ± 1 percent accuracy can be determined by the standard device. Record the stabilized air temperature and pressure upstream of the instrument and as required for the standard device.

(4) Calculate air flow at standard conditions as measured by both the standard device and the instrument.

(5) Repeat the procedures of paragraphs (b) through (d) above using flow rates which are 10 percent above the nominal sampling flow rate and 10 percent below the nominal sampling flow rate.

(6) If the air flow at standard conditions measured by the instrument differs by more than ± 1 percent from the standard measurement at any of the three measured flow rates, then a correction shall be made by either of the following two methods:

(i) Mechanically adjust the instrument so that it agrees within 1 percent of the standard measurement at the three specified flow rates, or

(ii) Develop a continuous best fit calibration curve for the instrument (as a function of the standard device flow measurement) from the three calibration points that represents the data to within 1 percent at all points to determine corrected flow.

(b) *Other systems.* A bell prover may be used to calibrate the instrument if the procedure outlined in ANSI B109.1–1973 is used. Prior approval by the Administrator is not required to use the bell prover.

24. A new § 86.1321–86 is added and reads as follows:

§ 86.1321–86 Hydrocarbon analyzer calibration.

The FID hydrocarbon analyzer shall receive the following initial and periodic calibration. The HFID shall be operated to a set point ±10°F (±5.5°C) between 365 and 385°F (185 and 197°C).

(a) Initial and periodic optimization of detector response. Prior to its introduction into service and at least annually thereafter the FID hydrocarbon analyzer shall be adjusted for optimum hydrocarbon response. Alternate methods yielding equivalent results may be used, if approved in advance by the Administrator.

(1) Follow the manufacturer's instructions for initial instrument start-up and basic operating adjustment using the appropriate fuel (see § 86.1314–86) and zero-grade air.

(2) Optimize on the most common operating range. Introduce into the analyzer, a propane in air mixture with a propane concentration equal to approximately 90% of the most common operating range.

(3) One of the following procedures is required for FID or HFID optimization.

(i) The procedures outlined in Society of Automotive Engineers (SAE) paper No. 770141, "Optimization of Flame Ionization Detector for Determination of Hydrocarbons in Diluted Automobile Exhaust"; author, Glenn D. Reschke.

(ii) The HFID optimization procedures outlined in 40 CFR 86, Subpart D.

(iii) Alternate procedures are allowed, if approved in advance by the Administrator.

(4) After the optimum flow rates have been determined, they are recorded for future reference.

(b) Initial and periodic calibration. Prior to its introduction into service and monthly thereafter the FID or HFID hydrocarbon analyzer shall be calibrated on all normally used instrument ranges. Use the same flow rate as when analyzing samples.

(1) Adjust analyzer to optimize performance.

(2) Zero the hydrocarbon analyzer with zero-grade air.

25. A new § 86.1322–86 is added and reads as follows:

§ 86.1322–86 Carbon monoxide analyzer calibration.

The NDIR carbon monoxide analyzer shall receive the following initial and periodic calibrations:

(a) Initial and periodic interference check. Prior to its introduction into service and annually thereafter the NDIR carbon monoxide analyzer shall be checked for response to water vapor and CO_2:

(1) Follow the manufacturer's instructions for instrument start-up and operation. Adjust the analyzer to optimize performance on the most sensitive range to be used.

(2) Zero the carbon monoxide analyzer with either zero-grade air or zero-grade nitrogen.

(3) Bubble a mixture of 3 percent CO_2 in N_2 through water at room temperature and record analyzer response.

(4) An analyzer response of more than 1 percent of full scale for ranges above 300 ppm full scale or more than 3 ppm on ranges below 300 ppm full scale will require corrective action. (Use of conditioning columns is one form of corrective action which may be taken.)

(b) Initial and periodic calibration. Prior to its introduction into service and

smoothly therefter the NDIR carbon monoxide analyzer shall be calibrated.

(1) Adjust the analyzer to optimize performance.

(2) Zero the carbon monoxide analyzer with either zero-grade air or zero-grade nitrogen.

(3) Calibrate on each used operating range with carbon monoxide in N_2 calibration gases having nominal concentrations of 15, 30, 45, 60, 75, and 90 percent of that range. Additional calibration points may be generated. For each range calibrated, if the deviaiton from a least-squares best-fit straight line is 2 percent or less of the value at each data point, concentration values may be calculated by use of a single calibration factor for that range. If the deviation exceeds 2 percent at any point, the best-fit non-linear equation which represents the data to within 2 percent of each test point shall be used to determine concentration.

(c) The initial and periodic interference, system check, and calibration test procedures specified in 40 CFR 86, Subpart D may be used in lieu of the procedures specified in this section.

26. A new § 86.1323–86 is added and reads as follows:

§ 86.1323–86 Oxides of nitrogen analyzer calibration.

The chemiluminescent oxides of nitrogen analyzer shall receive the following initial and periodic calibration.

(a) Prior to its introduction into service and weekly thereafter the chemiluminescent oxides of nitrgen analyzer shall be checked for NO_2 to NO converter efficiency. Figure N86–11 is a reference for the following steps:

(1) Follow the manufacturer's instructions for instrument start-up and operation. Adjust the analyzer to optimize performance.

(2) Zero the oxides of nitrogen analyzer with zero-grade air or zero-grade nitrogen.

(3) Connect the outlet of the NO_x generator to the sample inlet of the oxides of nitrogen analyzer which has been set to the most common operating range.

(4) Introduce into the NO generator analyzer-system an NO in nitrogen (N_2) mixture with a NO concentration equal to approximately 80 percent of the most common operating range. The NO_2 content of the gas mixture shall be less than 5 percent of the NO concentration.

(5) With the oxides of nitrogen analyzer in the NO mode, record the connection of NO indicated by the analyzer.

(6) Turn on the NO_x generator 0_2 (or air) supply and adjust the 0_2 (or air) flow rate so that the NO indicated by the analyzer is about 10 percent less than indicated in step (5). Record the concentration of NO in this $NO+O_2$ mixture.

(7) Switch the NO_x generator to the generation mode and adjust the generation rate so that the NO measured on the analyzer is 20 percent of that measured in step (5). There must be at least 10 percent unreacted NO at this point. Record the concentration of residual NO.

(8) Switch the oxides of nitrogen analyzer to the NO_x mode and measure total NO_x. Record this value.

(9) Switch off the NO_x generator but maintain gas flow through the system. The oxides of nitrogen analyzer will indicate the NO_x in the $NO+O_2$ mixture. Record this value.

(10) Turn off the NO_x generator O_2 (or air) supply. The analyzer will now indicate the NO_x in the original NO in N_2 mixture. This value should be no more than 5 percent above the value indicated in step (4).

(11) Calculate the efficiency of the NO_x converter by substituting the concentrations obtained intc the following equation:

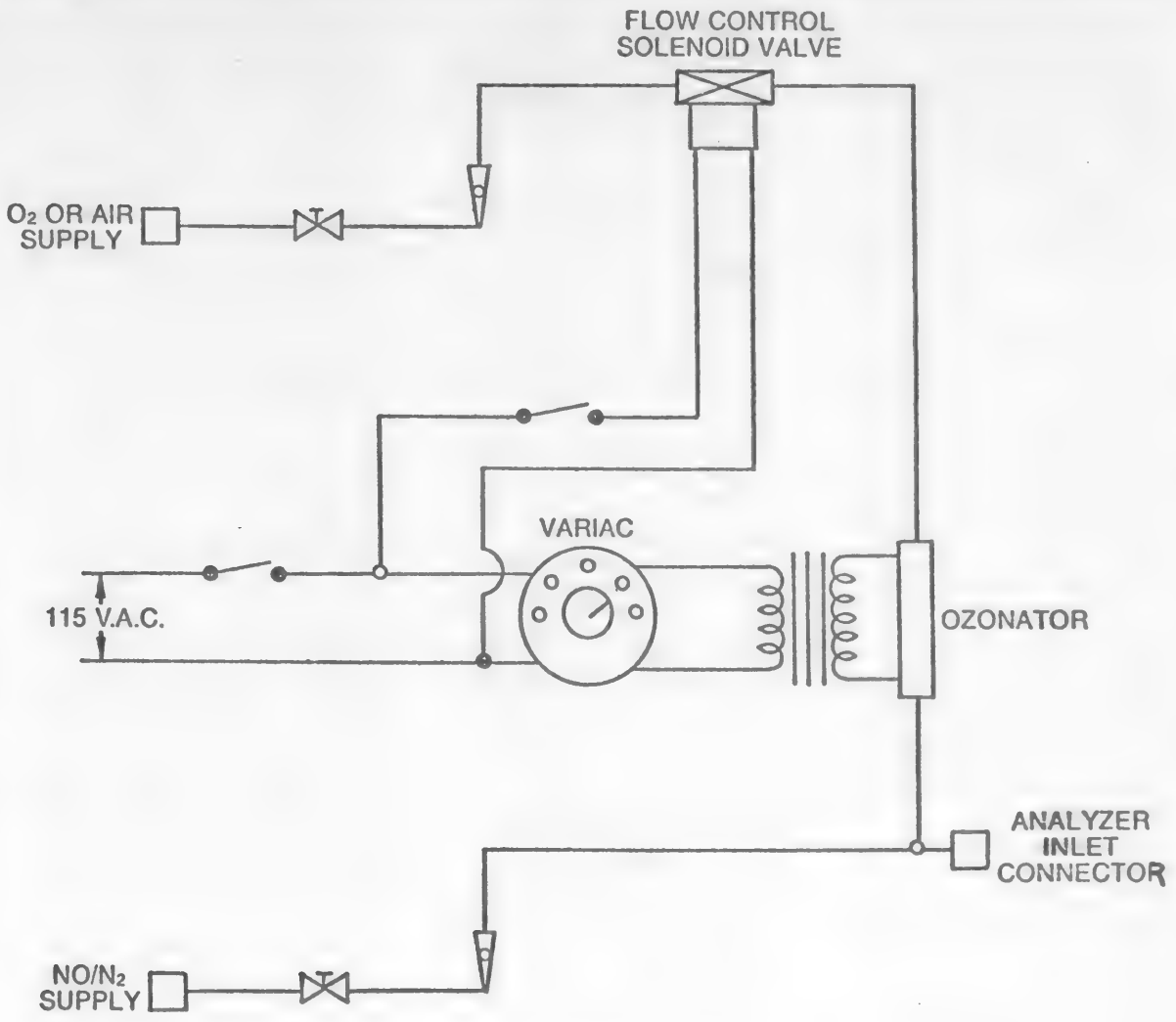
$$\text{Percent Efficiency} = [1+a-b/c-d)1\times 100$$

Where:

a = concentration obtained in step (8),
b = concentration obtained in step (9),
c = concentration obtained in step (6),
d = concentration obtained in step (7).

If converter efficiency is not greater than 90 percent corrective action will be required.

BILLING CODE 6560-26-M



(SEE FIG. N86-7 FOR SYMBOL LEGEND)

FIGURE N86-11 — NO_x CONVERTER EFFICIENCY DETECTOR

BILLING CODE 6560-26-C

(b) Initial and periodic calibration. Prior to its introduction into service and monthly thereafter the chemiluminescent oxides of nitrogen analyzer shall be calibrated on all normally used instrument ranges. Use the same flow rate as when analyzing samples. Proceed as follows:

(1) Adjust analyzer to optimize performance.

(2) Zero the oxides of nitrogen analyzer with zero-grade air or zero-grade nitrogen.

(3) Calibrate on each normally used operating range with NO in N_2 calibration gases with nominal concentrations of 15, 30, 45, 60, 75 and 90 percent of that range. For each range calibrated, if the deviation from a least-squares best-fit straight line is 2 percent or less of the value at each data point, concentration values may be calculated by use of a single calibration factor for that range. If the deviation exceeds 2 percent at any point, the best-fit non-linear equation which represents the data to within 2 percent of each test point shall be used to determine concentration.

(c) The initial and periodic interferences, system check, and calibration test procedures specified in 40 CFR 86, Subpart D may be used in lieu of the procedures specified in this section.

27. A new § 86.1324–86 is added and reads as follows:

§ 86.1324–86 Carbon dioxide analyzer calibration.

Prior to its introduction into service and monthly thereafter the NDIR carbon dioxide analyzer shall be calibrated as follows:

(a) Follow the manufacturer's instructions for instrument start-up and operation. Adjust the analyzer to optimize performance.

(b) Zero the carbon dioxide analyzer with either zero-grade air or zero-grade nitrogen.

(c) Calibrate on each normally used operating range with carbon dioxide in N_2 calibration gases having nominal concentrations of 15, 30, 45, 60, 75, and 90 percent of that range. Additional calibration points may be generated. For each range calibrated, if the deviation from a least-squares best-fit straight line is 2 percent of less of the value at each data point, concentration values may be calculated by use of a single calibration factor for that range. If the deviation exceeds 2 percent at any point, the best-fit non-linear equation which represents the data to within 2 percent of each test point shall be used to determine concentration.

(d) The initial and periodic interferences, system check, and calibration test procedures specified in 40 CFR 86, Subpart D may be used in lieu of the procedures in this section.

28. A new § 86.1325–86 is added and reserved as follows:

§86.1325–86 [Reserved]

29. A new § 86.1326–86 is added and reads as follows:

§ 86.1326–86 Calibration of other equipment.

Other test equipment used for testing shall be calibrated as often as required by the manufacturer or necessary according to good practice.

30. A new § 86.1327–86 is added and read as follows:

§ 86.1327–86 Engine dynamometer test procedures; overview.

(a) The engine dynamometer test procedure is designed to determine the brake-specific emission of hydrocarbons, carbon monoxide, oxides of nitrogen, and particulate (diesels only). The test procedure consists of a "cold" start test following either natural or forced cool-down periods described in §§ 86.1334–86 and 86.1335–86, respectively. A "hot" start test follows the "cold" start test after a hot soak of 20 minutes. The idle test of Subpart P may be run after the "hot start" test. The exhaust emissions are diluted with ambient air and a continuous proportional sample is collected for analysis during both the cold and hot start tests. The composite samples collected are analyzed either in bags or continuously for hydrocarbons (HC), carbon monoxide (CO), carbon dioxide (CO_2), and oxides of nitrogen (NO_x). In addition, for diesels only, particulates are collected on fluorocarbon coated glass fiber filters or fluorocarbon based (membrane) filters and the dilution air is prefiltered.

(b) Engine torque and rpm shall be recorded continuously during both the cold and hot start tests. Data points shall be recorded at least once every second.

(c) Using the torque and rpm feedback signals the brake horsepower is integrated with respect to time for the cold and hot cycles. This produces a brake horsepower-hour value that enables the brake-specific emissions to be determined (see § 86.1344–86, Calculations; exhaust emissions).

(d)(1) When an engine is tested for exhaust emissions or is operated for service accumulation on an engine dynamometer, the complete engine shall be tested, with all emission control devices installed and functioning.

(2) Evaporative emission controls need not be connected if data are provided to show that normal operating conditions are maintained in the engine induction system.

(3) On air cooled engines, the fan shall be installed.

(4) Additional accessories (e.g., oil cooler, alternators, air compressors, etc.) may be installed with advance approval by the Administrator.

(5) The engine must be equipped with a production type starter.

(e) Means of engine cooling which will maintain the engine operating temperatures (e.g., intake air, oil, water, etc.) at approximately the same temperature as specified by the manufacturer shall be used. Auxiliary fan(s) may be used to maintain engine cooling during operation on the dynamometer. Only water is allowed as an engine-coolant medium. Rust inhibitors and lubrication additives may be used, up to the levels recommended by the additive manufacturer. Antifreeze mixtures (e.g., ethylene glycol, alcohols) and other coolants that would enhance heat transfer are specifically prohibited.

(f) *Exhaust system.* A chasis-type exhaust system shall be used which is stabilized with respect to emissions. The exhaust system shall meet the following requirements:

(1) For all catalyst and trap-oxidizer systems, the distance from the exhaust manifold flange(s) to the catalyst or trap-oxidizer shall be the same as in the vehicle configuration unless the manufacturer provides data showing equivalent performance at another location.

(2) The exhaust back pressure or restriction shall be typical of those seen in the actual vehicle exhaust system configuration or the back pressure shall be the manufacturer's recommended maximum exhaust back pressure limit.

(3) For all diesel engines, the distance from the exhaust manifold flange to the exit of the chassis-type exhaust system shall be a maximum of 12 feet.

31. a new § 86.1328–86 is added and reserved as follows:

§ 86.1328–86 [Reserved]

32. A new § 86.1329–86 is added and reserved as follows:

§ 86.1329–86 [Reserved]

33. A new § 86.1330–86 is added as reads as follows:

§ 86.1330–86 Test sequence, general requirements.

(a) The test sequence shown in Figure N86–12 shows the major steps encountered as the test engine undergoes the procedures subsequently described.

BILLING CODE 6560-26-M

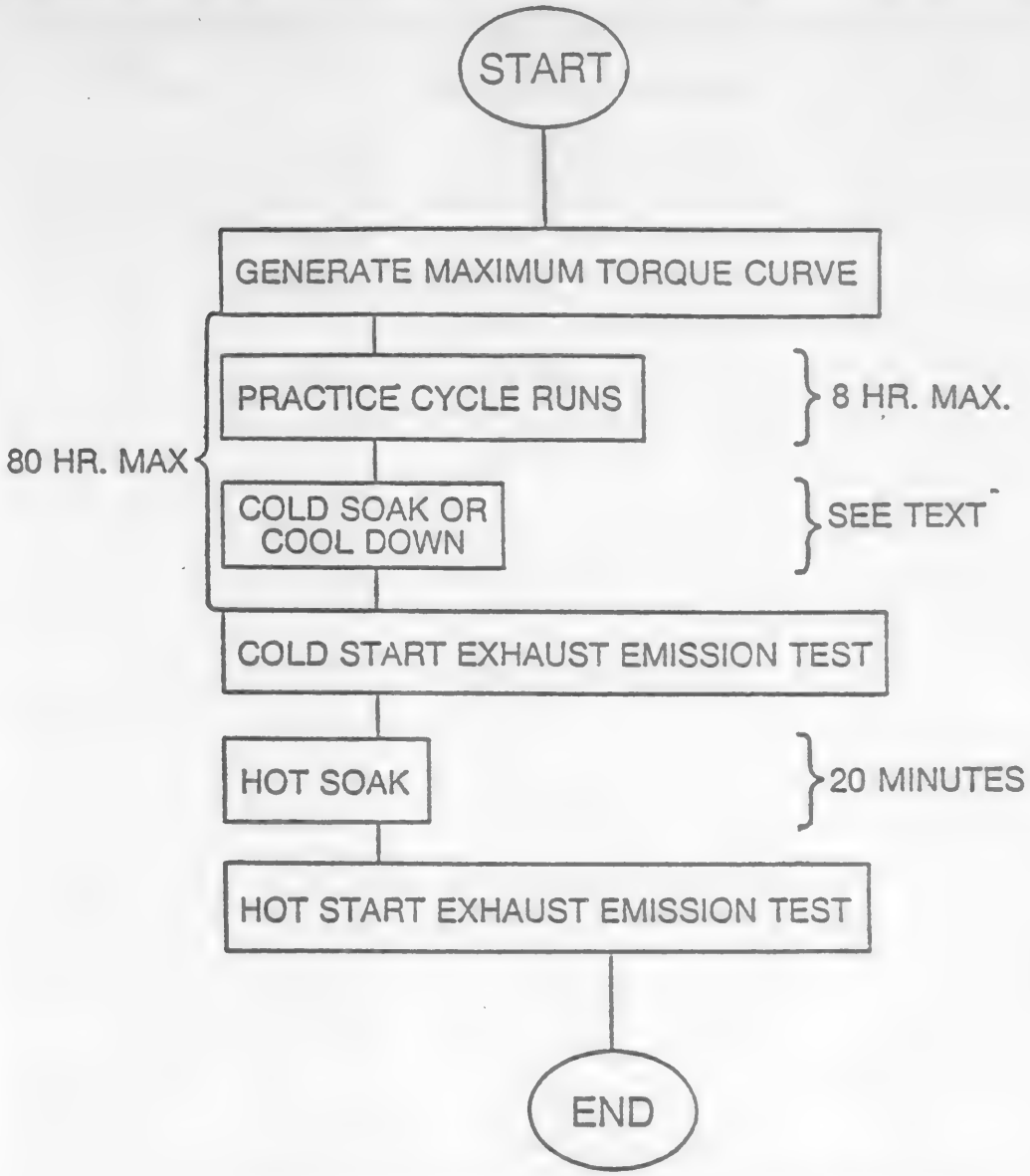


FIGURE N86-12 — TEST SEQUENCE

BILLING CODE 6560-26-C

(b) The average temperature of the engine intake air and CVS dilution air shall be maintained at 25° C ± 5° C (77°F ± 9° F) throughout the test sequence. Engines with auxiliary emission control devices which are temperature dependent (e.g., chokes, air cleaner, hot air doors, etc.) shall be tested at an average ambient test cell temperature 25° C ± 5°C throughout the test sequence, except as noted in § 86.1335–86.

(c) No control of ambient or CVS dilution air humidity is required. Engine intake air humidity shall not exceed 90 grains of water per pound of dry air.

(d) The idle test of Subpart P may be run after completion of the hot start exhaust emission test, if applicable.

(e) The barometric pressure observed during the generation of the maximum torque curve shall not deviate more than 1 in. Hg from the value measured at the beginning of the map. The barometric pressure observed during the exhaust emission test shall not deviate more than 1 in. Hg from the value measured at the beginning of the emission test. The average barometric pressure observed during the exhaust mission test must be within 1 in. Hg of the average observed during the maximum torque curve generation.

(f) *Diesel Engines only.* Air inlet and exhaust restrictions shall be set to represent the average restrictions which would be seen in use in a represenative application. Inlet depression and exhaust backpressure shall be set with the engine operating at maximum horsepower.

34. A new § 86.1331–86 is added and reserved as follows:

§ 86.1331–86 [Reserved]

35. A new § 86.1332–86 is added and reads as follows:

§ 86.1332–86 Engine mapping procedures.

(a) Mount test engine on the engine dynamometer.

(b) Determine minimum mapping speed.

(1) *Gasoline-fueled engines.* The minimum mapping speed shall be calculated from the following equations:

(i) Minimum Speed = Curb Idle RPM — 200 RPM; or

(ii) Minimum Speed = 400 RPM, whichever is greater.

(2) *Diesel-engines.* The minimum mapping speed shall be calculated from the following equations:

(i) Minimum Speed = Low Idle RPM — 200 RPM; or

(ii) Minimum Speed = 400 RPM, whichever is greater.

(c) Determine maximum mapping speed.

(1) *Gasoline-fueled.* (i) For ungoverned engines the maximum

$$\text{Maximum Speed} = \text{Curb Idle RPM} + \frac{115\left(\text{Measured Rated RPM} - \text{Curb Idle RPM}\right)}{100}$$

(ii) For governed engines the maximum mapped speed shall be either that speed at which the wide open throttle torque drops off to zero, or the maximum speed as calculated for

$$\text{Maximum Speed} = \text{Curb Idle RPM} + \frac{115\left(\text{Measured Rated RPM} - \text{Curb Idle RPM}\right)}{100}$$

(ii) For governed engines the maximum mapping speed shall be either that speed at which wide open throttle torque drops off to zero, or the maximum speed as calculated for ungoverned engines, whichever is smaller.

(d) Determine maximum torque curve (i.e., map the engine).

(1) During engine warm-up, the engine may be operated such that a preliminary estimate of measured rated speed can be made.

(2) *Gasoline-fueled engines.* (i) Start the engine and operate at zero load in accordance with the manufacturer's start-up and warm-up procedures for 1 minute ±30 seconds.

(ii) Operate the engine at a torque equivalent to 10±3 percent of the most recent determination of maximum torque for 4 minutes ±30 seconds at 2000 rpm.

(iii) Operate the engine at a torque equivalent to 55±5 percent of the most recent determination of maximum torque for 35 minutes ±1 minute at 2000 rpm.

(iv) Operate the engine at idle.

(v) Operate the throttle fully.

(vi) While still maintaining wide-open throttle and full-load obtain minimum engine speed. Maintain minimum engine speed for 15 seconds. Record the average torque during the last 5 seconds.

(vii) In no greater than 100 RPM increments, determine the maximum torque curve from minimum speed to maximum speed. Hold each test point for 15 seconds and record the average torque over the last 5 seconds.

(viii) *Alternate mapping technique.* In place of (d)(2)(vi) and (vii) above, a continual sweep of RPM is allowed. While operating at wide open throttle, the engine speed is increased at a constant 8 RPM/second (±1 RPM/second) from minimum speed to maximum speed. Speed and torque points shall be recorded at a sample rate of at least one point per second.

(ix) Recalculate minimum and maximum speeds per (b)(1) and (c)(1)(i) mapping speed shall be calculated from the following equations:

$$\text{Maximum Speed} = \text{Curb Idle RPM} + \frac{113\left(\text{Measured Rated RPM} - \text{Curb Idle RPM}\right)}{100}$$

ungoverned engines, whichever is smaller.

(2) *Diesel-engines.* (i) For ungoverned engines the maximum mapping speed shall be calculated from the following equation:

or (ii) of this section using the measured rated speed derived from the new maximum torque curve. If either of the new minimum or maximum speeds lay outside the range of speeds encompassed by the actual map, then the map shall be considered void. The entire mapping procedures shall be repeated, using the newly derived measured rated speed in all calculations.

(3) *Diesel engines.* (i) Start the engine and operate at free idle for 2 to 3 minutes.

(ii) Operate the engine at approximately 50 percent power at the peak torque speed for 5 to 7 minutes.

(iii) Operate the engine at rated speed and wide open throttle for 25 to 30 minutes.

(iv) *Option.* It is permitted to pre-condition the engine at rated speed and maximum horsepower until the oil and water temperatures are stabilized. The temperatures are defined as stabilized if they are maintained within 2 percent of point for 2 minutes. The engine must be opertated a minimum of 10 minutes for this option. This optional procedure may be substituted for step (iii).

(v) Unload the engine and operate at the low idle speed.

(iv) Operate the engine at wide open throttle and minimum engine speed. Increase the engine speed at a constant rate of 8 RPM/second (±1 RPM/second) from minimum to maximum speed. Engine speed and torque points shall be recorded at a sample rate of at least one point per second.

(vii) Recalculate minimum and maximum speeds per (b)(2) and (c)(2)(i) or (ii) of this section using the measured rated speed derived from the new maximum torque curve. If either of the new minimum or maximum speeds lay outside the range of speeds encompassed by the actual map, then the map shall be considered viod. The entire mapping procedure shall be repeated, using the newly derived measured rated speed in all calculations.

(e) Mapping curve generation.

(1) *Gasoline-fueled engines.* (i) Fit all data points recorded under (d)(2)(vi) and (vii) of this section (100 RPM increments) with a cubic spline technique.

(ii) All points generated under the continuous RPM sweep by step (d)(2)(vi) and (viii) shall be connected by linear interpolation between points.

(iii) For governed engines, all points above the maximum speed (see (c)(1)(ii) of this section) shall be assigned maximum torque values of zero for purposes of cycle generation.

(iv) For all engines, all speed points below 400 RPM shall be assigned a maximum torque value equal to that observed at 400 RPM for purposes of cycle generation.

(v) The torque curve resulting from step (i) through (iv) is the mapping curve and will be used to convert the normalized torque values in the engine cycle (see Appendix I, f) to actual torque values for the test cycle.

(2) *Diesel-engines.* (i) Connect all data points recorded under (d)(3) (vi) and (vii) of this section using linear interpolation between points.

(ii) For governed engines, all points above the maximum speed (see (c)(2)(ii) of this section) shall be assigned maximum torque values of zero for purposes of cycle generation.

(iii) For all engines, all speed points below 400 RPM shall be assigned a maximum torque value equal to that observed at 400 RPM for purposes of cycle generation.

(iv) The torque curve resulting from steps (i) through (iii) is the mapping curve and will be used to convert the normalized torque values in the engine cycle (see Appendix I, g) into actual torque values for the test cycle.

(f) *Alternate mapping and mapping curve generation techniques.* If a manufacturer believes that the above mapping techniques are unsafe or unrepresentative for any given engine or engine family, alternate mapping techniques may be used. Alternate techniques may be used only if approved in advance by the Administrator, and only if the Administrator judges that change to be justified, and the alternate procedure to be technically correct.

36. A new § 86.1333–86 is added and reads as follows:

§ 86.1333–86 Transient test cycle generation.

(a) The heavy-duty transient engine cycles for gasoline- and diesel-fueled engines are listed in Appendix I (f and g). These second-by-second listings are designed to represent transient torque and RPM maneuvers characteristic of heavy-duty vehicles. Both RPM and torque are normalized in these listings.

(1) To unnormalize RPM use the following equation:

$$\text{Actual RPM} = \frac{\%\text{RPM}(\text{Measured Rated RPM} - \text{Curb Idle RPM})}{100} + \text{Curb Idle RPM}$$

(Curb idle for diesel engines is defined as the low idle RPM.)

(2) Torque is normalized to the maximum torque at the RPM listed with it. Therefore, to unnormalize the torque values in the cycle, the maximum torque curve for the engine in question must be used. The generation of the maximum torque curve is described in § 86.1332.86.

(b) *Example of the unnormalization procedure.* The following test point shall be unnormalized:

Percent RPM	Percent torque
43	82

The test engines have these values:

Measured Rated RPM=3800 (Does not appear on given torque curve.)

Curb Idle RPM=600.

Maximum torque curve as illustrated in Figure N86–13.

Calculate actual RPM:

Actual RPM=percent RPM (Measured Rated RPM–Idle RPM)/100+Idle RPM

Actual RPM=43(3800–600)/100+600

Actual RPM=1976

Determine actual torque:

Determine the maximum torque at 1976 RPM from Figure N86–13. Then multiply this value (358 ft-lb) by 0.82. This results in an actual torque of 294 ft-lbs.

BILLING CODE 6560-25-M

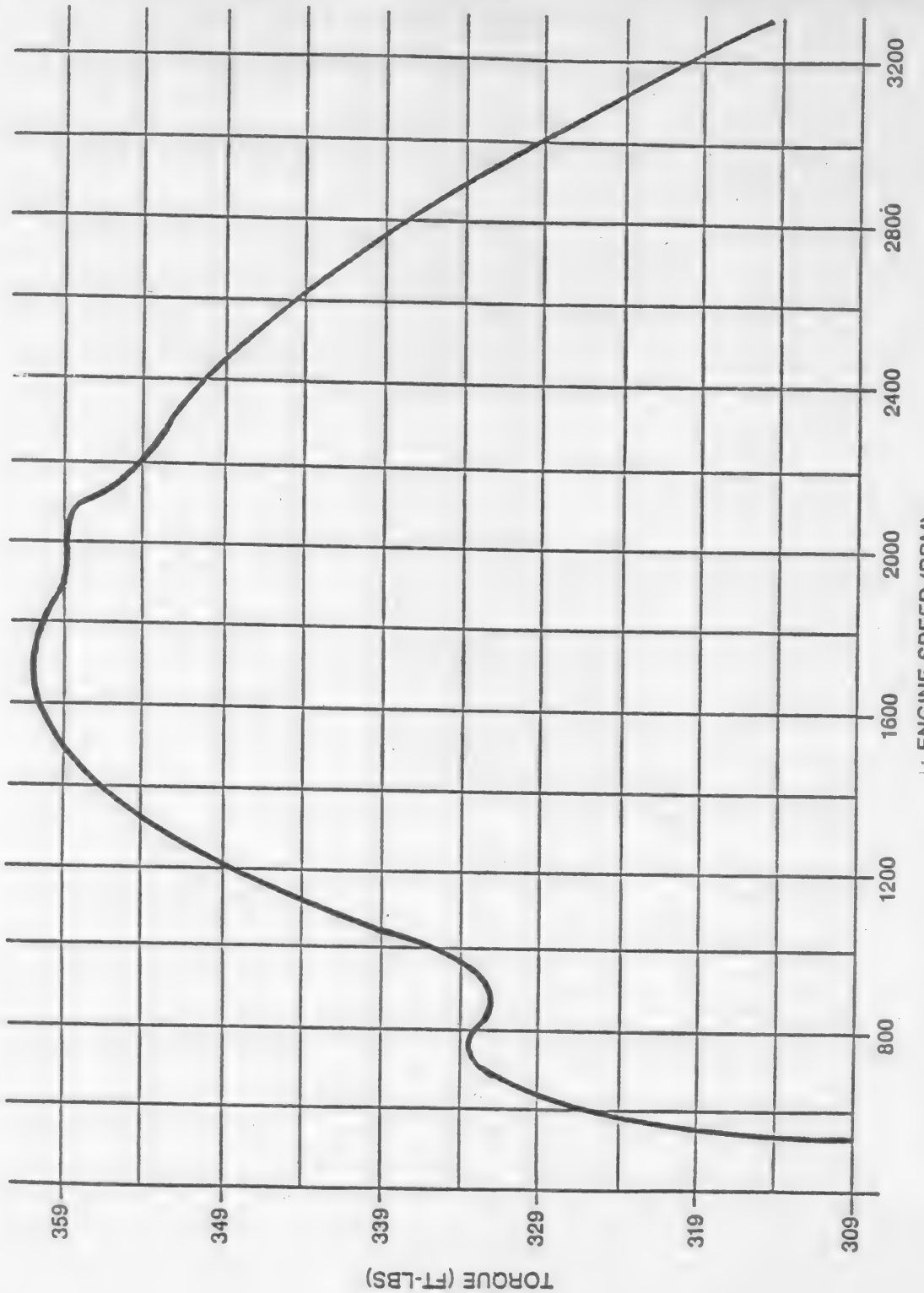


FIGURE N86-13— SAMPLE MAXIMUM TORQUE CURVE FOR A GASOLINE-FUELED ENGINE.

BILLING CODE 6560-26-C

(c) Engine speed and torque shall be recorded at least once every second during the cold start test and hot start test. The torque and RPM feedback signals may be electrically filtered.

(d) *Gasoline-fueled engines.* The zero percent speed specified in the gasoline-fueled engine cycle (Appendix I (f)) shall be superceded by proper operation of the engines automatic choke.

(1) During automatic choke operation a manual transmission engine shall be allowed to idle at whatever speed is required to produce a feedback torque of 0 ft-lbs ± 10 ft-lbs (using for example clutch disengagement, speed to torque control switching, software overrides, etc.) at those points in Appendix I where both reference speed and reference torque are zero percent values.

(2) During automatic choke operation an automatic transmission engine shall be allowed to idle at whatever speed is required to produce a feedback torque of CITT ft-lbs ± 10 ft-lbs (see (e)(2) of this section for definition of CITT) at those points in Appendix I where both reference speed and reference torque are zero percent values.

(3) This automatic choke high idle allowance is permitted only for the first 150 seconds of the cold cycle and the first 30 seconds of the hot cycle, after which the cycles shall be run as specified in Appendix I (f). (See 86.1341–86 for allowances in the cycle validation criteria.)

(e) *Automatic Transmissions.* The reference cycles Appendix I (f and g) shall be altered for engines intended for use with automatic transmissions.

(1) Zero percent speed for automatic transmission engines is defined as curb idle RPM, i.e., in-vehicle, coupled with automatic transmission in gear.

(2) All zero-percent speed, zero-percent torque points (idle points) shall be modified to zero percent speed, x percent torque. Using the manufacturers' specified curb idle transmission torque (CITT), the maximum torque available at the curb idle (i.e., with transmission) RPM as determined from the maximum torque curve generated in § 86.1332–86, x percent torque is defined per the following equation:

$$x\ \% = \frac{\text{CITT} \times 100}{\text{Maximum Torque at Curb Idle RPM}}$$

37. A new § 86.1334–86 is added and reads as follows:

§ 86.1334–86 Pre-test engine and dynamometer preparation.

Control system calibration. (a) Before the cold soak or cool down, final calibration of the dynamometer and throttle control systems may be performed. These calibrations may consist of steady-state operation and/or actual practice cycle runs, but emissions may not be measured.

(b) Following any practice runs or calibration procedures, the engine shall be turned off and allowed to either cold soak at 60° to 86°F for a minimum of 12 hours, or be cooled per § 86.1335–86.

38. A new § 86.1335–86 is added and reads as follows:

§ 86.1335–86 Optional forced cool-down procedure.

(a) This forced cool-down procedure applies to both gasoline and diesel-fueled engines.

(b) No substances or fluids may be applied to the engines internal or external surfaces except for water and air, and only as prescribed in (c) and (d) of this section.

(c) For water-cooled engines two types of cooling are permitted.

(1) Water may be circulated through the engine's water coolant system.

(i) The cooling water may be flowed in either direction and at any desired flow rate. The thermostat may be removed or blocked open during the cool down but must be restored before the exhaust emissions test begins.

(ii) The temperature of the circulated or injected water shall be between 10° C (50° F) and 30° C (86° F).

(iii) No fluid except water and no fluid or substance in solution with water is permitted. This does not preclude the use of a building's standard water supply for forced cool-down purposes.

(2) Flows of air may be directed at the exterior of the engine.

(i) Air shall be directed uniformly over the entire exterior surface of the engine at any desired flow rate.

(ii) The temperature of the cooling air shall not exceed 30° C (86° F). This is the only occasion when test cell ambient air temperature may deviate from the general specifications set forth in § 86.1330–86(b), i.e., may be less than 20° C (68° F).

(d) For air-cooled engines only cooling as prescribed in (c)(2) of this section is permitted.

(e) The cold cycle exhaust emission test may begin after a forced cool down only when the engine oil temperature as measured at the dipstick is between 20° C and 24° C (68° F and 75° F). No engine oil change is permitted during the test sequence, nor is any direct or indirect cooling of engine oil permitted except by natural conduction and convection associated with the procedures in (c) and (d) of this section.

(f)(1) The cold cycle exhaust emission test for gasoline engines equipped with catalytic converters may begin after a forced cool down only when the catalyst bed trempereature at the catalyst outlet is 25° C±5° C (77° F±9° F), in addition to the temperature restriction in (e) of this section.

(2) Catalyst cool down may be accomplished in whatever manner and using whatever coolant deemed appropriate by proper engineering judgment. The catalyst, engine, and exhaust piping configurations shall not be separated, altered, or moved in any way during the cool down.

(g) At the completion of the forced cool down, all general requirements specified in § 86.1330–86 and the oil temperature specification set forth in (e) of this section must be met before the cold cycle exhaust emission test may begin.

39. A new § 86.1336–86 is added and reads as follows:

§ 86.1336–86 Engine starting and restarting.

(a) *Gasoline-fueled engines.* This paragraph applies to gasoline-fueled engines only.

(1) The engine shall be started with a production engine starter motor according to the manufacturer's recommended starting procedures in the owner's manual. The 24±1 second free idle period shall begin when the engine starts.

(2) *Choke operation:* (i) Engines equipped with automatic chokes shall be operated according to the manufacturer's operating instructions in the owner's manual, including choke setting and "kick-down" from cold fast idle.

(ii) Engines equipped with manual chokes shall be operated according to the manufacturer's operating instructions in the owner's manual.

(3) The operator may use the choke, throttle, etc. where necessary to keep the engine running.

(4) If the manufacturer's operating instructions in the owner's manual do not specify a warm engine starting procedure, the engine (automatic- and manual-choke engines) shall be started by depressing the throttle half way and cranking the engine until it starts.

(b) *Diesel engines.* The engine shall be started with a production engine starting-motor according to the manufacturer's recommended starting procedures in the owner's manual. The 24±1 second free idle period shall begin when the engine starts.

(c)(1) If the engine does not start after 15 seconds of cranking, cranking shall cease and the reason for failure to start

shall be determined. The gas flow measuring device (or revolution counter) on the constant volume sampler (and the hydrocarbon integrator and particulate sample pump(s) when testing diesel vehicles, see § 86.1337, Engine dynamometer test run) shall be turned off during this diagnostic period. In addition, either the CVS should be turned off or the exhaust tube disconnected from the tailpipe during the diagnostic period. If failure to start is an operational error, the engine shall be rescheduled for testing from a cold start.

(2) If longer cranking times are recommended to the ultimate purchaser, such cranking times may be used provided the owner's manual and the service repair manual indicate the longer cranking times are normal, and if the use of the longer cranking times is approved in advance by the Administrator.

(3) If a failure to start occurs during the cold portion of the test and is caused by an engine malfunction, corrective action of less than 30 minutes duration may be taken (according to § 86.084–25), and the test continued. The sampling system shall be reactivated at the same time cranking begins. When the engine starts, the timing sequence shall begin. If failure to start is caused by engine malfunction and the engine cannot be started, the test shall be voided and corrective action may be taken according to § 86.084–25. The reasons for the malfunction (if determined) and the corrective action taken shall be reported to the Administrator.

(4) If a failure to start occurs during the hot start portion of the test and is caused by engine malfunction, the engine must be started within one minute of key on. The sampling system shall be reactivated at the same time cranking begins. When the engine starts, the transient engine cycle timing sequence shall begin. If the engine cannot be started within one minute of key on, the test shall be voided, corrective action taken, (according to § 86.084–25), and the engine rescheduled for testing. The reason for the malfunction (if determined) and the corrective action taken shall be reported to the Administrator.

(d) If the engine "false starts," the operator shall repeat the recommended starting procedure (such as resetting the choke, etc.).

(e) *Engine stalling.* (1) If the engine stalls during the initial idle period of either the cold or hot start test, the engine shall be restarted immediately using the appropriate cold or hot starting procedure and the test continued. If the engine cannot be started before the first non-idle record of the cycle, the test shall be voided.

(2) If the engine stalls anywhere in the cold cycle, except in the initial idle period, the test shall be voided.

(3) If the engine stalls on the hot cycle portion of the test at any time up to and including 580 seconds into the hot cycle, the engine may be shut off and resoaked for 20 minutes. The hot cycle may then be rerun. Any stalling of the engine or voiding of the hot cycle more than 580 seconds into the hot cycle shall result in a void test. Only one hot start resoak and restart is permitted.

40. A new § 86.1337–86 is added and reads as follows:

§ 86.1337–86 Engine dynamometer test run.

(a) The following steps shall be taken for each test:

(1) Prepare the engine, dynamometer, and sampling system for the cold start tests. Change filters, etc. and leak check as necessary.

(2) Connect evacuated sample collection bags to the dilute exhaust and dilution air sample collection systems.

(3) Start the CVS (if not already on), the sample pumps, except the diesel particulate sample pump(s), if applicable, the temperature recorder, the engine cooling fan(s) and any data collection system (i.e., chart recorders, computers, data loggers, etc.). The heat exchanger of the constant volume sampler (if used), and the heated components of any continuous sampling system(s) (if applicable) shall be preheated to their respective operating temperatures before the test begins. See § 86.1304–86(e) for continuous sampling procedures.

(4) Adjust the sample flow rates to the desired flow rate and set the CVS gas flow measuring devices to zero.

Note.—CFV–CVS sample flow rate is fixed by the venturi design.

(5) Attach the CVS flexible exhaust tube to engine tailpipe(s).

(6) Carefully install a clean particulate sample filter into each of the filter holders for diesel tests. The filters must be handled with forceps or tongs. Rough or abrasive filter handling will result in erroneous weight determination.

(7) Follow the manufacturer's choke and throttle instructions for cold starting. Simultaneously start the engine and begin exhaust and dilution air sampling. For diesel engines, turn on the hydrocarbon, continuous NO_x, CO, or CO_2 (if used) analyzer(s) system integrator(s) and turn on the particulate sample pumps and indicate the start of the test on the data collection medium (i.e., mark the chart on a chart recorder, set a byte on a computer or data logger, etc.).

(8) As soon as it is determined that the engine is started, start a "free idle" timer.

(9) Allow the engine to idle freely with no-load for 24±1 seconds. This idle period for automatic transmission engines may be interpreted as an idle speed in neutral or park. All other idle conditions shall be interpreted as an idle speed in gear. It is permissible to lug the engine down to curb idle speed during the last 8 seconds of the free idle period for the purpose of engaging dynamometer control loops.

(10) Begin the transient engine cycles such that the first non-idle record of the cycle occurs at 25±1 seconds. The free idle time is included in the 25±1 seconds.

Note.—During diesel testing, adjust the sample pump(s) so that the flow rate through the particulate sample probe or transfer tube is maintained at a constant value within ±5 percent of the set flow rate. Record the average temperature and pressure at the gas meter(s) or flow instrumentation inlet. If the set flow rate cannot be maintained because of high particulate loading on the filter, the test shall be terminated. The test shall be rerun using lower flow rate and/or a larger diameter filter.

(11) On the last record of the cycle cease sampling, immediately turn the engine off, and start a hot soak timer. For diesel engines immediately after the engine stops running, simultaneously turn off the gas flow measuring device(s) and the diesel hydrocarbon integrator, mark the hydrocarbon recorder chart, and turn off the particulate sample pump(s).

(12) Immediately after the engine is turned off, turn off the engine cooling fan(s) if used, and the CVS blower. As soon as possible transfer the "cold start cycle" exhaust and dilution air bag samples to the analytical system and process the samples according to § 83.1340–86 obtaining a stabilized reading of the exhaust sample on all analyzers within 20 minutes of the end of the sample collection phase of the test. For diesel engines carefully remove each particulate sample filter from its holder and place each in a petri dish, and cover.

(13) Allow the engine to soak for 20 ± 1 minutes.

(14) Prepare the engine and dynamometer for the hot start test.

(15) Connect evacuated sample collection bags to the dilute exhaust and dilution air sample collection systems.

(16) Start the CVS (if not already on), the sample pumps (except the diesel particulate sample pump(s), if applicable), the temperature recorder,

the engine cooling fan(s) and any data collection system (i.e., chart recorders, computers, data loggers, etc.). The heat exchanger of the constant volume sampler (if used) and the heated components of any continuous sampling system(s) (if applicable) shall be preheated to their respective operating temperatures before the test begins. See § 86.1340–86(e) for continuous sampling procedures.

(17) Adjust the sample flow rates to the desired flow rate and set the CVS gas flow measuring devices to zero.

Note.—CFV–CVS sample flow rate is fixed by the venturi design.

(18) Carefully install a clean particulate filter into each of the filter holders for diesel tests. The filters must be handled only with forceps or tongs. Rough or abrasive filter handling will result in erroneous weight determination.

(19) Follow the manufacturer's choke and throttle instruction for hot starting. Simultaneously start the engine and begin exhaust and dilution air sampling. For diesel engines, turn on the hydrocarbon analyzer system integrator, mark the recorder chart, and turn on the particulate sample pump(s).

(20) As soon as it is determined that the engine is started, start a "free idle" timer.

(21) Allow the engine to idle freely with no-load for 24 ± 1 seconds. The provisions and interpretations of step (a)(8) of this section apply.

(22) Begin the transient engine cycle such that the first non-idle record of the cycle occurs at 25 ± 1 seconds. The free idle is included in the 25 ± 1 seconds.

(23) On the last record of the cycle cease sampling. For diesel engines, simultaneously turn off gas flow measuring device(s) and the diesel hydrocarbon integrator, mark the hydrocarbon recorder chart, and turn off the particulate sample pump(s).

(24) As soon as possible transfer the "hot start cycle" exhaust and dilution air bag samples to the analytical system and process the samples according to § 86.1340–86 obtaining a stabilized reading of the exhaust sample on all analyzers within 20 minutes of the end of the sample collection phase of the test.

(25) For diesel engines, carefully remove each particulate sample filter from its holder and place each in a clean petri dish and cover as soon as possible. Within one hour after the end of the hot start phase of the test, transfer the four particulate filters to the weighing chamber for post-test conditioning.

(26) The CVS and the engine may be turned off, if desired.

(b) The procedure in paragraph (a) of this section is designed for one sample bag for the cold start portion and one for the hot start portion. It is permissible to use 4 sample bag per test portion. The bags shall sample for the portion of the cycle as indicated below:

Bag No.	Sample time	
	Gasoline-[illegible]	[illegible]
1	272	297
2	579	597
3	[illegible]	[illegible]
4	1167	1199

41. A new § 86.1338–86 is added and reads as follows:

§ 86.1338–86 Emission measurement accuracy.

(a) Measurement accuracy for analysis systems used for bag measurements.

(1) Good engineering practice would dictate that analyzer readings below 15 percent of full scale chart deflection should generally not be used.

(2) Some high resolution read-out systems such as computers, data loggers, etc., can provide sufficient accuracy and resolution below 15 percent of full scale. Such systems may be used provided that additional calibration bottles are added to insure that the calibration curves below 15 percent of full scale, in the region of the sample measurements, conforms to the accuracy specifications in § 86.1316–86 through § 86.1326–86.

(b) Measurement accuracy for analysis systems used for continuous measurement systems.

(1) Analyzers used for continuous analysis must be operated such that the integrated concentration value over the test cycle falls between 15 and 100 percent of full scale chart deflection. Exceptions to these limits are:

(i) The analyzer's response may be less than 15 percent or more than 100 percent of full scale if automatic range change circuitry is used and the limits for range changes are between 15 and 100 percent of full-scale chart deflection;

(ii) The analyzer's response may be less than 15 percent of full scale if:

(A) Alternative (a)(2) of this section is used to insure that the accuracy of the calibration curve is maintained below 15 percent; or

(B) The full-scale value is 155 ppmC or less; or

(C) The emissions from the engine are erratic and the integrated chart deflection value is greater than 15 percent of full scale; or

(D) The contribution of all data read below the 15 percent level is less than 10 percent by mass of the final test results.

(iii) During engine start-up the HC analyzer is allowed to "spike" off-scale for a maximum of 5 seconds.

42. A new § 86.1339–86 is added and reads as follows:

§ 86.1339–86 Diesel particulate filter handling and weighing.

(a) At least 1 hour, but not more than 80 hours before the test, place each filter in an open, but protected, petri dish and place in the weighing chamber which meets the humidity and temperature specifications of § 86.1312–86.

(b) At the end of the 1 to 80 hour stabilization period, weigh the filter on a balance having a precision of one microgram. Record this weight. This reading is the tare weight.

(c) The filter shall then be stored in a covered petri dish which shall remain in the weighing chamber until needed for testing.

(d) If the filter is not used within one hour of its removal from the weighing chamber, it shall be re-weighed.

(e) After the test, and after the sample filter is returned to the weighing room, condition it for at least 1 hour but not more than 80 hours. Then weigh a second time. This latter reading is the gross weight of the filter. Record this weight.

(f) The net weight (M_{PT}) is the gross weight minus the tare weight.

Note.—Should the sample on the filter contact the petri dish or any other surface, the test is void and must be re-run.

43. A new § 86.1340–86 is added and reads as follows:

§ 86.1340–86 Exhaust sample analysis.

(a) The analyzer response may be read by automatic data collection (ADC) equipment such as computers, data loggers, etc. If ADC equipment is used the following is required.

(1) For bag analysis the analyzer response must be stable at greater than 99 percent of final reading. A single value representing the average chart deflection over a 10 second stablized period may be stored.

(2) For continuous analysis systems, the ADC system must store at least 5 chart deflection readings per second.

(3) The chart deflections in (a) (1) and (2) of this section may be stored on long term computer storage devices such as computer tapes, storage discs, punch cards, or they may be printed in a listing for storage. In either case a chart recorder is not required and records from a chart recorder, if they exist, need not be stored.

(4) If the data from ADC equipment is used as permanent records, the ADC equipment and the analyzer values as interpreted by the ADC equipment are subject to the calibration specifications in §§ 86.1316–86 through 86.1326–86, as if the ADC equipment were part of the analyzer.

(b) Data records from any one or a combination of analyzers may be stored as chart recorder records.

(c) *Software zero and span.* (1) The use of "software" zero and span is permitted. The process of software zero and span refers to the technique of initially adjusting the analyzer zero and span responses to the calibration curve values, but for subsequent zero and span checks the analyzer response is simply recorded without adjusting the analyzer gain. The observed analyzer response recorded from the subsequent check is mathematically corrected back to the calibration curve values for zero and span. The same mathematical correction is then applied to the analyzer's response to a sample of exhaust gas in order to compute the true sample concentration.

(2) The maximum amount of software zero and span mathematical correction is ±10 percent of full scale chart deflection.

(3) Software zero and span may be used to switch between ranges without adjusting the gain of the analyzer.

(4) The software zero and span technique may not be used to mask analyzer drift. The observed chart deflection before and after a given time period or event shall be used for computing the drift. Software zero and span may be used after the drift has been computed to mathematically adjust any span drift so that the "after" span check may be transformed into the "before" span check for the next segment.

(d) For bag sample analysis perform the following sequence:

(1) Warm-up and stabilize the analyzers.

(2) Clean and/or replace filter elements, conditioning columns (if used), etc., as necessary.

(3) The order of steps (1) and (2) may be interchanged.

(4) Obtain a stable zero reading.

(5) Zero and span the analyzers with zero and span gases. The span gases shall have concentrations between 75 and 100 percent of full scale chart deflection. The flow rates and system pressures during spanning shall be approximately the same as those encountered during sampling.

(6) Re-check zero response, repeat paragraphs (d)(4) and (d)(5) of this section or use software zero and span if necessary.

(7) If a chart recorder is used, identify the most recent zero and span response as the pre-analysis values.

(8) If ADC equipment is used, electronically record the most recent zero and span response as the pre-analysis values.

(9) Measure HC (except diesels), CO, CO_2, and NO_x concentrations in the sample bag(s) with approximately the same flow rates and pressures used in paragraph (d)(5) of this section. Constituents measured continuously do not require bag analysis.

(10) Rechecking of the zero and span point after the analysis of the bag is permitted. The number of bags that may be analyzed after pre-analysis values for zero and span have been determined is not specified. The limiting criteria on the time span or the number of events that may occur between the pre-analysis and post-analysis zero span checks are the following:

(i) A pre-analysis zero and span value for each range of each constituent to be analyzed must be determined and identified or recorded prior to analyzing the bag. The bag may be sampled in order to identify the specific range required prior to the determination of the pre-analysis values.

(ii) A post-analysis zero and span check for each range used must be performed and the values recorded. The time interval or the number of events that may occur between the pre and post checks is not specified. However, the difference between pre-analysis zero and span values (recorded in step (7) and (8)) versus those recorded for the post-analysis check may not exceed the zero drift limit or the span drift limit of 2 percent of full scale chart deflection for any range used.

(iii) The time span between the pre and post checks may be no longer than the time period that was used to evaluate the analyzer drift performance.

(11) Analyze the remaining sample and background bags as outlined in steps (4) through (10).

(e) For continuous sample analysis perform the following sequences:

(1) Warm-up and stabilize the analyzers.

(2) Clean and/or replace filter elements, conditioning columns (if used) etc., as necessary.

(3) The order of steps (1) and (2) may be interchanged.

(4) Leak check portions of the sampling system that operate under a vacuum when sampling.

(5) Allow heated sample lines, filters, pumps, etc., to stabilize at operating temperature.

(6) The order of steps (4) and (5) may be interchanged.

(7) Obtain a stable zero reading.

(8) Zero and span each range to be used on each analyzer used prior to the beginning of the cold cycle. The span gases shall have a concentration between 75 and 100 percent of full scale chart deflection. The flow rates and system pressures shall be approximately the same as those encountered during sampling.

(9) Re-check zero response, repeat steps (7) and (8) or use software zero and span if necessary.

(10) If a chart recorder is used, identify the most recent zero and span response as the pre-analysis values.

(11) If ADC equipment is used, electronically, record the most recent zero and span response as the pre-analysis values.

(12) Measure the emissions (HC required for diesels, NO_x, CO, CO_2 optional) continuously during the cold start cycle. Indicate the start of the test, the range(s) used, and the end of the test on the recording medium (chart paper or ADC equipment). Use approximately the same flow rates and system pressures used in step (8).

(13) Collect background HC, CO, CO_2, and NO_x in a sample bag.

(14) Perform a post-analysis zero and span check for each range at the conditions specified in step (8).

(15) Neither the zero drift nor the span drift between the pre-analysis and post-analysis checks on any range used may exceed 3 percent for HC or 2 percent for NO_x, CO, and CO_2 of full scale chart deflection, or the test is void.

(16) Determine HC background levels for the cold start cycle by introducing a sample from the background bag into the overflow HC span system.

(17) Determine background levels of NO_x, CO, or CO_2 (if necessary) by the technique outlined in paragraph (e) of this section. The continuous analyzers may be used for analysis under paragraph (e).

Note.—For a quality control check on diesel HC, compare an analysis of a background bag to a continuous analysis of background air sampled through the total hydrocarbon probe. For best results, the difference should be less than 1 percent on the average (time integrated) dilute hydrocarbon emission level during the test.

(18) Repeat steps (7) through (17) for the hot cycle. The post-analysis zero and span check for the cold start (or previous hot start) cycle may be used for the pre-analysis zero and span for the following hot start cycle.

(19) If the HC drift is greater than 3 percent of full-scale chart deflection, hydrocarbon hang-up is suspected.

(f) HC hang-up. If the HC hang-up is suspected, the following sequence may be performed.

(1) Fill a clean sample bag with zero gas.

(2) Zero and span the HFID with the overflow system.

(3) Analyze the sample bag through the overflow sample system.

(4) Analyze tha sample bag on another FID or HFID meeting the specification of this Subpart or 40 CFR, Subpart D that does not have a hang-up problem.

(5) If the difference between the readings obtained is 3 percent or more of the HFID full scale, disconnect probe and clean same. (Soaking with sulfuric acid has proven effective.) Clean sample line also. (Heating to 450° F and flow nitrogen gas continuously for 12 hours has proven useful.)

(6) Reassembe the sample system, heat to specified temperature, and repeat the procedure in (1) through (6) above.

44. A new § 86.1341–86 is added and reads as follows:

§ 86.1341–86 Test cycle validation criteria.

(a) To reduce errors between the feedback and reference (cycle trace) values the engine speed and torque feedback signals may be shifted a maximum of ±5 seconds with respect to the reference speed and torque traces. If the feedback signals are shifted, both speed and torque must be shifted the same amount in the same direction.

(b) Calculate the brake horsepower for each pair of engine speed and torque values recorded. Also calculate the reference brake horsepower for each pair of engine speed and torque reference values. Calculations shall be to five significant digits.

(c) Linear regressions of feedback value on reference value shall be performed for speed, torque and brake horsepower. The method of least-square shall be used. The equation shall have the form:

$$y = mx + b$$

Where:

y = The feedback (actual) value of speed (in RPM), Torque (in ft-lbs.), or brake horsepower.

m = Slope of the regression line.

x = The reference value (speed, torque, or brake horsepower).

b = The y intercept of the regression line.

(d) The standard error of estimate (SE) of y on x and the coefficient of determination (r^2) shall be calculated for each regression line.

(e) For a valid test the criteria in Figure N86–14 must be met for both cycles (cold start and hot start) individually. Deletions from the regression analysis are permitted where allowed in Figure N86–14.

BILLING CODE 6560–26–M

REGRESSION LINE TOLERANCES

	SPEED	TORQUE	BRAKE HORSEPOWER
STANDARD ERROR OF ESTIMATE (SE) OF Y ON X	100 RPM	13% OF MAXIMUM ENGINE TORQUE	8% OF MAXIMUM BRAKE HORSEPOWER
SLOPE OF THE REGRESSION LINE, M	0.970-1.030	0.83-1.03 HOT 0.77-1.03 COLD	0.89-1.03 (HOT) 0.87-1.03 (COLD)
COEFFICIENT OF DETERMINATION, R^2	0.9700 1/	0.8800 (HOT) 1/ 0.8500 (COLD) 1/	0.9100 1/
Y INTERCEPT OF THE REGRESSION LINE, B	± 50 RPM	± 15 FT. LBS.	± 5.0 OF BRAKE HORSEPOWER

1/ MINIMUM

PERMITTED POINT DELETIONS FROM REGRESSION ANALYSIS

CONDITION	POINTS TO BE DELETED
FIRST 24 SECONDS (± 1) OF FREE IDLE OF HOT AND COLD CYCLES	SPEED, TORQUE, BRAKE HORSEPOWER
WIDE OPEN THROTTLE { SPEED CONTROL: TORQUE FEEDBACK < TORQUE REFERENCE }	TORQUE, BRAKE HORSEPOWER
WIDE OPEN THROTTLE { TORQUE CONTROL: SPEED FEEDBACK < SPEED REFERENCE }	SPEED, BRAKE HORSEPOWER
SPEED CONTROL, CLOSED THROTTLE, TORQUE REFERENCE < ZERO	TORQUE, BRAKE HORSEPOWER
GASOLINE FUELED ENGINES EQUIPPED WITH AUTOMATIC CHOKES; FIRST 150 SECONDS OF COLD CYCLE OR FIRST 30 SECONDS OF HOT CYCLE, CLOSED THROTTLE AND: MANUAL TRANSMISSION, IF TORQUE FEEDBACK	
A: IS EQUAL TO ZERO (± 10 FT. LBS.) OR;	SPEED, BRAKE HORSEPOWER
B. AUTOMATIC TRANSMISSION, IF TORQUE FEEDBACK IS EQUAL TO CURB IDLE TRANSMISSION TORQUE (± 10 FT. LBS.)	SPEED, BRAKE HORSEPOWER

FIGURE N86-14

BILLING CODE 6560-26-C

(f) The integrated brake horsepower-hour for each cycle (cold and hot start) shall be between −15 percent and +5 percent of the integrated brake horsepower-hour for the reference cycle or the test is void. All torque and speed data points must be used to calculate the intergrated brake horsepower-hour. For the purposes of this calculation, negative torque values (i.e., motoring horsepower) shall be set equal to zero and included.

(g) If a dynamometer test run is determined to be statistically or experimentally void, corrective action shall be taken. The engine shall then be allowed to cool (naturally or forced) and the dynamometer test rerun per § 86.1337–86.

45. A new § 86.1342–86 is added and reads as follows:

§ 86.1342–86 Calculations; exhaust emissions.

(a) The final reported transient emission test results shall be computed by use of the following formula:

$$A_{wm} = \frac{1/7(g_C) + 6/7(g_H)}{1/7(BHP\text{-}Hr_C) + 6/7(BHP\text{-}Hr_H)}$$

Where:

A_{wm} = Weighted mass emission level (HC, CO, CO_2, NOx or particulate (diesel only)) in grams per brake horsepower hour.

g_C = Mass emission level in grams, measured during the cold start test.

g_H = Mass emissions level in grams, measured during the hot start test.

$BHP\text{-}HR_C$ = Total brake horsepower-hour (brake horsepower integrated with respect to time) for the cold start test.

$BHP\text{-}HR_H$ = Total brake horsepower-hour (brake horespower integrated with respect to time) for the hot start test.

(1) The mass of each pollutant for the cold start test and the hot start test for bag measurements and diesel heat exchanger sample system measurements is determined from the following equations:

(i) Hydrocarbon mass:

$$HC_{mass} = V_{mix} \times Density_{HC} \times (HC_{conc}/1{,}000{,}000)$$

(ii) Oxides of nitrogen mass:

$$NOx_{mass} = V_{mix} \times Density_{NO_2} \times K_H \times (NOx_{conc}/1{,}000{,}000)$$

(iii) Carbon monoxide mass:

$$CO_{mass} = V_{mix} \times Density_{CO} \times (CO_{conc}/1{,}000{,}000)$$

(iv) Carbon dioxide mass:

$$CO_{2mass} = V_{mix} \times Density_{CO_2} \times (CO_{2conc}/100)$$

(v) Diesel particulate mass:

$$P_{mass} = [V_{mix} + V_{Sf}] \times \frac{P_f}{V_{Sf}}$$

(2) The mass of each pollutant for the cold start test and the hot start test for flow compensated sample systems is determined from the following equations:

$$\text{(i) } HC_{mass} = \sum_{i=1}^{n} \left[\frac{(HC_e)_i \times (\dot{V}_{mix})_i \times (\text{Density HC}) \times \Delta T}{10^6} \right] - \frac{HC_d}{10^6} \left(1 - \frac{1}{DF}\right) \times V_{mix} \times \text{Density}_{HC}$$

$$\text{(ii) } NOx_{mass} = \sum_{i=1}^{n} \left[\frac{(NOx_e)_i \times (\dot{V}_{mix})_i \times (\text{Density}_{NO_2}) \times \Delta T}{10^6} \right] - \frac{NOx_d}{10^6} \left(1 - \frac{1}{DF}\right) \times V_{mix} \times \text{Density}_{NO_2}$$

$$\text{(iii) } CO_{mass} = \sum_{i=1}^{n} \left[\frac{(CO_e)_i \times (\dot{V}_{mix})_i \times (\text{Density}_{CO}) \times \Delta T}{10^6} \right] - \frac{CO_d}{10^6} \left(1 - \frac{1}{DF}\right) \times V_{mix} \times \text{Density}_{CO}$$

$$\text{(iv) } CO_{2mass} = \sum_{i=1}^{n} \left[\frac{(CO_{2_e})_i \times (\dot{V}_{mix})_i \times (\text{Density}_{CO_2}) \times \Delta T}{10^6} \right] - \frac{CO_{2_d}}{10^6} \left(1 - \frac{1}{DF}\right) \times V_{mix} \times \text{Density}_{CO_2}$$

(3) Meaning of symbols:

(i) HC_{mass} = Hydrocarbon emissions, in grams per test phase.

$Density_{HC}$ = Density of hydrocarbons is 16.33 g/ft³ (.5768 kg/m³), assuming an average carbon to hydrogen ratio of 1:1.85, at 68°F (20°C) and 760 mm Hg (101.3 kPa) pressure.

HC_{conc} = Hydrocarbon concentration of the dilute exhaust sample corrected for background, in ppm carbon equivalent, i.e., equivalent propane X 3.

$HC_{conc} = HC_e - HC_d[1-(1/DF)]$

Where:

HC_e = Hydrocarbon concentration of the dilute exhaust bag sample or, for diesel heat exchanger systems, average hydrocarbon concentration of the dilute exhaust sample as calculated from the integrated HC traces, in ppm carbon equivalent. For flow compensated sample systems $(HC_e)_i$ is the instantaneous concentration.

HC_d = Hydrocarbon concentration of the dilution air as measured, in ppm carbon equivalent.

(ii) NOx_{mass} = Oxides of nitrogen emissions, in grams per test phase.

$Density_{NO2}$ = Density of oxides of nitrogen is 54.16 g/ft³ (1.913 kg/m³), assuming they are in the form of nitrogen dioxide, at 68°F (20°C) and 760 mm Hg (101.3 kPa) pressure.

NOx_{conc} = Oxides of nitrogen concentration of the dilute exhaust sample corrected for background, in ppm.

$NOx_{conc} = NOx_e - NOx_d[1-(1/DF)]$

Where:

NOx_e = Oxides of nitrogen concentration of the dilute exhaust bag sample as measured, in ppm. For flow compensated sample systems $(NOx_e)_i$ is the instantaneous concentration.

NOx_d = Oxides of nitrogen concentration of the dilute air as measured, in ppm.

(iii) CO_{mass} = Carbon monoxide emissions, in grams per test phase.

$Density_{CO}$ = Density of carbon monoxide is 32.97 g/ft³ (1.164 kg/m³), at 68°F (20°C) and 760 mm Hg (101.3 kPa) pressure.

CO_{conc} = Carbon monoxide concentration of the dilute exhaust sample corrected for background, water vapor, and CO_2 extraction, in ppm.

$CO_{conc} = CO_e - CO_d[1-(1/DF)]$

Where:

CO_e = Carbon monoxide concentration of the dilute exhaust bag sample volume corrected for water vapor and carbon dioxide extraction, in ppm. For flow compensated sample systems $(CO_e)_i$ is the instantaneous concentration. The calculation assumes the carbon to hydrogen ratio of the fuel is 1:1.85.

$CO_e = [1-0.01925CO_{2e}-0.000323R]CO_{em}$

Where:

CO_{em} = Carbon monoxide concentration of the dilute exhaust sample as measured, in ppm.

CO_{2e} = Carbon dioxide concentration of the dilute exhaust bag sample, in percent. For flow compensated sample systems $(CO_{2e})_i$ is the instantaneous concentration.

R = Relative humidity of the dilution air, in percent (see § 86.1342–86(a)(5)).

CO_d = Carbon moxide concentration of the dilution air corrected for water vapor extraction, in ppm.

$CO_d = [1-0.000323R]CO_{dm}$

Where:

CO_{dm} = Carbon monoxide concentration of the dilution air sample as measured, in ppm.

Note.—If a CO instrument which meets the criteria specified in § 86.1311–86 is used and the conditioning column has been deleted, CO_{em} can be substituted directly for CO_e and CO_{dm} can be substituted directly for CO_d.

(iv) CO_{2mass} = Carbon dioxide emissions, in grams per test phase.

$Density_{CO2}$ = Density of carbon dioxide is 51.85 g/ft³ (1.843 kg/m³), at 68°F (20°C) and 760 mm Hg (101.3 kPa) pressure.

CO_{2conc} = Carbon dioxide concentration of the dilute exhaust sample corrected for background, in percent.

$CO_{2conc} = CO_{2e} - CO_{2d}[1-(1/DF)]$

Where:

CO_{2d} = Carbon dioxide concentration of the dilution air as measured, in percent.

(v) P_{mass} = Mass of particulate determined in grams per test phase.

P_f = Mass of particulate per test on the exhaust filter (or filters if the back-up filter is required. See § 86.1310–86(c) for determination), grams.

V_{sf} = Total volume of sample removed from the primary dilution tunnel, cubic feet at standard conditions.

(a) For a single-dilution system:

$$V_{sf} = \frac{V_{as} \times (P_B + P_{is}) \times 528°R}{T_{is} \times 760\ mmHG}$$

Where:

V_{as} = actual volume of dilute sample removed from the primary-dilution tunnel, cubic feet.

P_B = barometric pressure, mmHg.

P_{is} = pressure elevation above ambient measured at the inlet to the dilute exhaust sample gas meter or flow instrumentation, mmHg. For most gas meters or flow instruments with unrestricted discharge P_{is} is negligible and can be assumed = 0.

T_{is} = average temperature of the dilute exhaust sample at the inlet to the gas meter or flow instrumentation, °R.

Note.—V_{sf} may require correction according to § 86.1320–86(f).

(b) For a double-dilution system:

$V_{sf} = V_{pf}$

Where:

$V_{vf} = V_{av} \times (P_B + P_{iv}) \times 528°R/T_{iv} \times 760$ mmHG

V_{av} = actual volume of double diluted sample which passed through the particulate filter, cubic feet.

P_B = barometric pressure, mmHg.

P_{iv} = pressure elevation above ambient measured at the inlet to the sample gas meter located at the exit side of the secondary dilution tunnel, mmHg. For most meters with unrestricted discharge P_{iv} is negligible and can be assumed=0.

T_{iv} = Average temperature of the dilute exhaust sample at the inlet to the exit side gas meter or flow instrumentation, °R.

$V_{pf} = V_{ap} \times (P_B + P_{ip}) \times 528°R/T_{ip} \times 760$ mmHG

V_{ap} = actual volume of secondary dilution air, cubic feet.

P_B = barometric pressure, mmHg.

P_{ip} = pressure elevation above ambient measured at the inlet to the sample gas meter or flow instrumentation located at the inlet side of the secondary dilution tunnel, mmHg. For most gas meters with unrestricted discharge P_{ip} is negligible and can be assumed=0.

T_{ip} = Average temperature of the dilute exhaust sample at the inlet to the inlet side gas meter or flow instrumentation, °R.

Note.—Both V_{vf} and V_{pf} may require correction according to § 86.1320–86(f). These corrections must be applied before V_{sf} is determined.

Note.—The background particulate level inside the dilution air filter box at EPA is very low. This particulate level will be assumed=0, and background particulate samples will not be taken with each exhaust sample. It is recommended that background particulate checks be made periodically to verify the low level. Any manufacturer may make the same assumption without prior EPA approval.

(vi) $DF = 13.4/[CO_{2e} + (HC_e + CO_e) \times 10^{-4}$

K_H + Humidity correction factor.

For gasoline engines:

$K_H = 1/[1 - 0.0047(H - 75)]$ (or for SI units $= 1/[1 - 0.0329(H - 10.71)]$)

For diesel engines:

$K_H = 1$.

Where:

H = Absolute humidity in grains (grams) of water per pound (kilogram) of dry air.

$H = [(43.478)R_a \times P_d]/[P_B - (P_d \times R_a/100)]$ for SI units, $H = [(6.211)R_a \times P_d]/[P_B - (P_d \times R_a/100)]$

R_a = Relative humidity of the ambient air, in percent.

P_d = Saturated vapor pressure, in mm Hg (kPa) at the ambient dry bulb temperature.

P_B = Barometric pressure, in mm Hg (kPa).

Dt = Time interval (in seconds) between samples in flow compensated systems (0.2 seconds maximum).

V_{mix} = Total dilute exhaust volume in cubic feet per test phase corrected to standard conditions (528°R (293°K) and 760 mm Hg (101.3 kPa).

$(V_{mix})_i$ = Instantaneous dilute exhaust volumetric flow rate (for compensated flow systems), in cubic feet per second.

For PDP–CVS, V_{mix} is:

$$V_{mix} = V_o \times \frac{N(P_B - P_A)(528°R)}{(760\ mm\ Hg)(T_p)}$$

for SI units,

$$V_{mix} = V_o \times \frac{N(P_B - P_A)(293.15°K)}{(101.3\ kPa)(T_p)}$$

Where:

V_o = Volume of gas pumped by the positive displacement pump, in cubic feet (cubic metres) per revolution. This volume is dependent on the pressure differential across the positive displacement pump.

N = Number of revolutions of the positive displacement pump during the test phase while samples are being collected.

P_B = Barometric pressure, in mm Hg (kPa).

P_A = Pressure depressions below atmospheric measured at the inlet to the positive displacement pump, in mm Hg (kPa) (during an idle mode).

T_p = Average temperature of dilute exhaust entering positive displacement pump during test, °R (°K).

(b) Sample calculation of mass values of exhaust emissions:

(1) Assume the following test results for a gasoline engine:

	Cold start cycle test results	Hot start cycle test results
V_{mix}	6924 ft³	6873 ft³.
R	30.2%	30.2%.
R_a	30.2%	30.2%.
P_B	735 mm Hg	735 mm Hg.
P_d	22.676 mm Hg	22.676 mm Hg.
HC_c	132.07 ppm C equiv.	86.13 ppm C equiv.
NOx_c	7.86 ppm	10.98 ppm.
CO_{mc}	171.22 ppm	114.28 ppm.
CO_{2c}	.178%	.381%.
HC_d	3.60 ppm C equiv.	8.70 ppm C equiv.
NOx_d	0.0 ppm	0.10 ppm.
CO_{dm}	0.89 ppm	0.89 ppm.
CO_{2d}	0.0%	0.38%.
BHP-HR	0.259	0.347.

Then:

Cold Start Test

$H = [(43.478)(30.2)(22.676)]/[735 - (22.676)(30.2)/100] = 41$ grains of water per pound of dry air.

$K_H = 1/[1 - 0.0047(41 - 75)] = 0.862$

$CO_c = [1 - 0.01925(.178) - 0.000323(30.2)]171.22 = 169.0$ ppm

$CO_d = [1 - 0.000323(30.2)]0.89 = .881$ ppm

$DF = 13.4/[.178 + (132.1 + 168.9)(10^{-5})] = 64.392$

$HC_{conc} = 132.1 - 3.6[1 - (1/64.265)] = 128.6$ ppm

$HC_{mass} = 6924(16.33)(128.6/1,000,000) = 14.53$ grams

$NOx_{conc} = 7.86 - 0.0[1 - (1/64.265)] = 7.86$ ppm

$NOx_{mass} = 6924(54.16)(.862)(7.86/1,000,000) = 2.54$ grams

$CO_{conc} = 169.0 - .881[1 - (1/64.265)] = 168.0$ ppm

$CO_{mass} = 6924(32.97)(168.0/1,000,000) = 38.35$ grams

$CO_{2conc} = .178 - 0[1 - /64.265)] = .178\%$

$CO_{2mass} = 6924(51.85)(.178/100) = 639$ grams

Hot Start Test

Assume similar calculations result in the following:

$HC_{mass} = 8.72$ grams

$NOx_{mass} = 3.49$ grams

$CO_{mass} = 25.70$ grams

$CO_{2mass} = 1226$ grams

(2) Weighted mass emission results:

$$HC_{wm} = \frac{1/7(14.53) + 6/7(8.72)}{1/7(0.259) + 6/7(0.347)}$$

$= 28.6$ grams/BHP-HR

$$NOx_{wm} = \frac{1/7(2.54) + 6/7(3.49)}{1/7(0.259) + 6/7(0.347)}$$

$= 10.0$ grams/BHP-HR

$$CO_{wm} = \frac{1/7(38.35) + 6/7(25.70)}{1/7(0.259) + 6/7(0.347)}$$

$= 82.2$ grams/BHP-HR

$$CO_{2wm} = \frac{1/7(639) + 6/7(1226)}{1/7(0.259) + 6/7(0.347)}$$

$= 3415$ grams/ BHP-HR

(c) The final reported brake-specific fuel consumption (BSFC) shall be computed by use of the following formula:

$$BSFC = \frac{1/7(M_C) + 6/7(M_H)}{1/7(BHP\text{-}HR_C) + 6/7(BHP\text{-}HR_H)}$$

Where:

BSFC = brake-specific fuel consumption in pounds of fuel per brake horsepower-hour (lbs/BHP–HR)

M_C = mass of fuel, in pounds, used by the engine during the cold start test.

M_H = mass of fuel, in pounds, used by the engine during the hot start test.

$BHP\text{–}HR_C$ = total brake horsepower-hours (brake horsepower integrated with respect to time) for the cold start test.

$BHP\text{–}HR_H$ = total brake horsepower-hours (brake horsepower integrated with respect to time) for the hot start test.

(1) The mass of fuel for the cold start and hot start test is determined from the following equation:

$$M = (G_s/R_2)(1/453.6)$$

(2) Meaning of symbols:

M = Mass of fuel, in pounds, used by the engine during the cold or hot start test.

G_s = Grams of carbon measured during the cold or hot start test.

$$G_s = [12.011/(12.011 + \alpha(1.008))]HC_{mass} + 0.429CO_{mass} + 0.273\ CO_{2mass}$$

Where:

HC_{mass} = Hydrocarbon emissions, in grams for cold or hot start test.

CO_{mass} = Carbon monoxide emissions, in grams for cold or hot start test.

CO_{2mass} = Carbon dioxide emissions, in grams for cold or hot start test.

α = The measured hydrogen to carbon ratio of the fuel.

R_2 = The grams of carbon in the fuel per gram of fuel.

$R_2 = 12.011/[12.011 + \alpha(1.008)]$

(d) Sample calculation of brake-specific fuel consumption:

(1) Assume the following text results:

BILLING CODE 6560-26-M

	Cold Start Cycle Test Results	Hot Start Cycle Test Results
BHP-HR	6.945	7.078
α	1.85	1.85
HC_{mass}	37.08 grams	28.82 grams
CO_{mass}	357.69 grams	350.33 grams
CO_{2mass}	5419.62 grams	5361.32 grams

Then:

G_s for cold start test =
$[12.011/(12.011 + (1.85)(1.008))](37.08) + 0.429(357.69) + 0.273(5419.62) = 1665.10$ grams

G_s for hot start test =
$[12.011/(12.011 + (1.85)(1.008))](28.82) + 0.429(350.33) + 0.273(5361.32) = 1638.88$ grams

$R_2 = 12.011/[12.011 + 1.85(1.008)] = .866$

$M_C = (1665.10/.866)(1/453.6) = 4.24$ lbs.

$M_H = (1638.88/.866)(1/453.6) = 4.17$ lbs.

(2) Brake-specific fuel consumption results:

$$BSFC = \frac{1/7(4.24) + 6/7(4.17)}{1/7(6.945) + 6/7(7.078)} = .592 \text{ lbs.of fuel/BHP-HR}$$

BILLING CODE 6560-26-C

46. A new § 86.1343–86 is added and reserved as follows:

§ 86.1343–86 [Reserved]

47. A new § 86.1344–86 is added and reads as follows:

§ 86.1344–86 Required information.

(a) The required test data shall be grouped into the following three general categories:

(1) Engine set-up and descriptive data. This data must be provided to the EPA supervisor of engine testing for each engine sent to the Administrator for confirmatory testing prior to the initiation of engine set-up. This data is necessary to insure that EPA test personnel have the correct data in order to set up and test the engine in a timely and proper manner. This data is not required for tests performed by the manufacturers.

(2) Pre-test data. This data is general test data that must be recorded for each test. The data is of a more descriptive nature such as identification of the test engine, test site number, etc. As such, this data can be recorded at any time within 24 hours of the test.

(3) Test-data. This data is physical test data that must be recorded at the time of testing.

(b) All data may be supplied to the Administrator by punch cards, magnetic tape, or other electronic data processing means. Acceptable data formats and transmission techniques will be provided in the Application Format for Certification of the applicable Model Year.

(c) Engine set-up data. Because the specific test facilities may change somewhat with time, the specific data parameters and number of items may vary slightly. The Application Format for Certification for the applicable Model Year will specify the exact requirements. In general, the following type of data will be required:

(1) Engine manufacturer.

(2) Engine system combination.

(3) Engine code and CID.

(4) Engine identification number.

(5) Applicable engine model year.

(6) Engine fuel type.

(7) Recommended oil type.

(8) Exhaust pipe configuration pipe sizes, etc.

(9) Curb idle speed.

(10) Dynamometer idle speed. (Automatic transmission engines only.)

(11) Engine parameter specifications such as spark timing, operating temperature, advance curves, etc.

(12) Engine performance data such as, maximum BHP, rated speed, fuel flow, governed speed, etc.

(13) Recommended start-up procedure.

(14) Maximum safe engine operating speed.

(15) Number of hours of operation accumulated on engine.

(16) Manufacturer's recommended inlet depression limit and typical in-use inlet depression level.

(17) Exhaust system.

(i) *Diesel engines.* (A) Header pipe inside diameter.

(B) Tailpipe inside diameter.

(C) Minimum distance in-use between the exhaust manifold flange and the exit of the chassis exhaust system.

(D) Manufacturer's recommended maximum exhaust back pressure limit for the engine.

(E) Typical back pressure as determined by the maximum back pressure application of the engine.

(F) Minimum back pressure required to meet applicable noise regulations.

(ii) *Gasoline-fueled engines.* Typical in-use back pressure in vehicle exhaust system.

(d) Pre-test data. The following data shall be recorded, and reported to the Administrator for each test conducted for Compliance with the provisions of 40 CFR 86, Subpart A:

(1) Engine-system combination.

(2) Engine identification.

(3) Instrument operator(s).

(4) Engine operator(s).

(5) Number of hours of operation accumulated on the engine prior to beginning the test sequence (Figure N86–12).

(6) Fuel identification with average of test fuel used.

(7) Date of most recent analytical assembly calibration.

(8) All pertinent instrument information such as tuning, gain, serial numbers, detector number, calibration curve number, etc. As long as this information is traceable, it may be summarized by system number or analyzer identification numbers.

(e) *Test data.* The physical parameters necessary to compute the test results and insure accuracy of the results shall be recorded for each test conducted for compliance with the provisions of 40 CFR 86, Subpart A. Additional test data may be recorded at the discretion of the manufacturer. Extreme details of the test measurements such as analyzer chart deflections will generally not be required on a routine basis to be reported to the Administrator for each test, unless a dispute about the accuracy of the data arises. The following type of data shall be required to be reported to the Administrator. The Application Format for Certification for the applicable Model Year will specify the exact requirements which may change slightly from year to year with the addition or deletion of certain items.

(1) Date and time of day.

(2) Test number.

(3) Engine intake air or test cell temperature.

(4) Barometric pressure.

Note.—A central laboratory barometer may be used; *Provided,* that individual test cell barometric pressure are shown to be within ±0.1 percent of the barometric pressure at the central barometer location.

(5) Engine intake or test cell and CVS dilution air humidity.

(6) Maximum torque versus speed curve as determined in § 86.1332, with minimum and maximum engine speeds.

(7) Measured maximum horsepower, maximum torque, and rated speeds.

(8) Measured maximum horsepower and torque.

(9) High idle engine speed (diesel engines only).

(10) Fuel consumption at maximum power and torque (diesel engines only).

(11) Curb-idle fuel flow rate.

(12) Cold soak time interval and cool down procedures.

(13) Temperature set point of the heated continuous analysis system components (if applicable).

(14) Test cycle validation criteria as specified in § 86.1341 for each test phase (cold-hot).

(15) Total CVS flow rate with dilution factor for each test phase (cold-hot).

(16) Sample concentrations (background corrected) for HC, CO, CO_2, and NO_x for each test phase (cold-hot).

(17) Brake specific emissions (g/BHP-hr) for HC, CO and NO_x for each test phase (cold-hot).

(18) The weighted (cold-hot) brake specific emissions (g/BHP-hr) for the total test.

(19) The weighted (cold-hot) carbon balance brake specific fuel consumption for the total test.

(20) The number of hours of operation accumulated on the engine after completing the test sequences described in Figure N86–10.

(21) *Additional required records for diesel engines.* (i) Pressure and temperature of the dilute exhaust mixture and secondary-dilution air in the case of a double-dilution system at the inlet to the respective gas meter(s) or flow instrumentation used for particulate sampling.

(ii) The temperature of the dilute exhaust mixture immediately before the particulate filter.

(iii) Gas meter or flow instrument readings at the start of each sample period and at the end of each sample period.

(iv) The stabilized pre-test weight and post-test weight of each particulate sample filter.

(v) The temperature and humidity of the ambient air in which the particulate filters were stabilized.

(vi) The temperatures of the gas (1) flowing in the heated sample line before the heated filter and (2) before the HFID, and the temperature of the control system of the heated hydrocarbon detector.

[FR Doc. 81-257 Filed 1-6-81; 8:45 am]
BILLING CODE 6560-25-M